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HOW FLORAL PERFUMES ARE MADE IN FRANCE.

THE recent visit of the Queen of England to the French town of Grasse on the Mediterranean gives interest to the following account of perfume making as carried on in that place.

At one time the chief source of wealth for Grasse was its leather trade, but its tanneries were crushed out of existence by the fiscal laws of the Revolution, and since then the principal industry has been the making of perfumes and preserved fruits. Not that the making of perfumes is a modern industry at Grasse, for it dates from the time of Catherine de Medicis, who sent a Florentine named Turbarelli to open a laboratory here, and her chief physician, Dona di Roberto, paid occasional visits to Grasse in order to see how things were going on. But at that time the quantity of scent made was very small, and scarcely any of it was sold, whereas now the annual consumption of flowers used by the large manufacturers is enormous, being estimated at 1,200 tons of orange blossoms, 800 tons of roses, 200 tons of jasmine, 100 tons of violets, and 30 tons of tuberose. Most of these flowers are grown in the fields, which form a vast carpet of variegated color between here and Cannes. The manufactories in which the scent is made are among the most interesting sights of Grasse. The most important industry next to that of perfumery is the trade in oil, there being about thirty oil-mills in and around Grasse for crushing the olives which grow in abundance on the slopes of the mountains. Preserved fruits, candied or crystallized, or set in glazed sugar, as well as sirups and jellies, make a large confectionery trade. Soap was at one time made here in large quantities, utilizing the lard which had served in extracting perfume from the flowers; but this manufacture has failed before the competition of Marseilles. Grasse has also a great export of flowers, which may form the bouquets of distant fashionable ball rooms, wedding parties, opera boxes, and costly funeral wreaths. The details of this elegant business would be an interesting study.

Of the perfumes manufactured at Grasse, the most precious are the otto of roses and the "neroli," which latter is made from the flowers of the bitter orange tree, and is used principally in the manufacture of eau de cologne. The otto of roses of Grasse is superior to that of Turkey. Extracts for scenting pocket-handkerchiefs are made from freshly gathered flowers laid between two sheets of glass. On each side of the glass is a layer of lard, which, in twelve to twenty-four hours, completely absorbs the odoriferous oil. When the flowers are abundant, they are renewed every twelve hours, sometimes every six hours. The operation is repeated a different number of times on the same lard with different flowers. Jonquils are changed thirty times, the cassia and violet sixty, the tuberose (a kind of hyacinth) and the jasmine both eighty times. The lard is melted in a large iron vessel, and mixed with spirits made from grain, which combining with the volatile oil rises to the top; the fluid is then filtered; this is called the cold method. Orange and rose petals require the hot methods, either by the still or by the "bain-marie." The distilling of the fragrant oil from the petals requires most vigilant attention. Rose and orange pomade are made by the bain-marie method by submerging a large iron pot full of lard in boiling water. When the lard is melted the petals are added, and after having remained twelve or twenty-four hours the mass is filtered to remove the now inodorous petals. The operation is repeated from thirty to sixty times, according to the required strength of the perfume.—*Illustrated London News.*



THE PERFUMERY MANUFACTURE AT GRASSE—SORTING ROSES.

A CENTURY OF PATENT LAWS.*

By Justice S. BLATCHFORD, U. S. Supreme Court.

I HAVE been requested by the committee which has charge of the ceremonies of this celebration of the beginning of the second century of the American patent system to address you on the subject of "A Century of Patent Law."

As we derive the principles of our statutory and administrative patent law from England, it seems proper to regard the subject as covering English patent law, to a certain extent.

Prior to the English statute of 21 James I., chapter 3, passed in 1623, entitled "An act concerning monopolies and dispensations with penal laws and the forfeiture thereof," commonly called "the Statute of Monopolies," it was customary for the King, by virtue of his prerogative, to grant exclusive privileges or monopolies to individuals according to his pleasure, and not because of any invention or discovery which the individual had made, or had been the first to introduce into the kingdom. To such an extent was this carried that Edward III. granted to two persons a patent of privilege for the sole making of "the Philosopher's Stone;" and by subsequent sovereigns, patents were granted for the sole manufacture of playing cards and for an exclusive right to sell various necessaries of life.

By the Statute of Monopolies, all monopolies were abolished as contrary to law, excepting grants to the first inventor of any manner of new manufacture, of the sole privilege of working or making the same. The statute did not bring such grants into existence, but excepted them out of the grants of monopolies, and left them to depend upon the common law for their legality.

James I., in 1610, had made a public declaration that all grants of monopolies and of the benefit of any penal laws, or of power to dispense with the law, or to compound for the forfeiture, were contrary to the laws of the kingdom, and had commanded that no suitor should presume to move the King for matters of that nature.

Section 1 of the Statute of Monopolies declared that all monopolies theretofore granted, or thereafter to be granted, for the sole making or using of anything, should be void. Section 6 of the act provided that the inhibition should not extend to a patent of privilege "of the sole working or making of any manner of new manufactures within this realm to the true and first inventor" thereof, which others at the time of making the grant "shall not use, so as also they be not contrary to the law, nor mischievous to the State, by raising prices of commodities at home, or hurt of trade, or generally inconvenient," their duration to be for 21 years from their date, in respect to patents theretofore granted for more than 21 years, and to be for 14 years or under in respect to patents thereafter to be granted.

For many years after the passing of this statute, the arts and manufactures continued in a low state in England, and few of the inventions patented were of any value. Until the reign of George III., the law reports are almost entirely silent respecting patent privileges; and almost the only case reported during that period is that of *Edgeberry & Stephens* (2 *Salkeld*, 447), where it was held, construing the statute of 21 James I., that "if the invention be new in England, a patent may be granted, though the thing was practiced beyond the sea before; for the statute speaks of new manufactures within this realm; so that if they be new here, it is within the statute, for the act intended to encourage

* Abstract of address delivered at the Patent Centennial Celebration, Washington, April 8, 1891.

new devices useful to the kingdom, and whether learned by travel or by study, it is the same thing."

Since that decision, it has been the uniform practice in England to grant letters patent to a person who introduces an invention not used before within the kingdom; and Parliament has repeatedly recognized the principle, by granting exclusive privileges to such introducers.

The first case of importance respecting a patent was an action of *scire facias* brought against Sir Richard Arkwright (*The King* v. *Arkwright*, 1 *Webster*, 60), to repeal his patent for an invention of a machine for preparing material for spinning, which action was tried in June, 1785.

About ten years afterward the important cases of *Boulton & Watt* v. *Bull* (2 *Hen. Black.* 463) and *Hornblower* v. *Boulton & Watt* (8 *Term R.* 95), in regard to the great invention of James Watt in steam engines, were tried, in which the patent law was much discussed, and many of its difficulties and obscurities were cleared away. In the second of the above cases, the patent granted to Watt in 1769 was held by the Court of King's Bench to be valid.

Since that time the issue of patents for inventions has increased steadily, the interests involved in them have assumed immeasurable importance and magnitude, and the principles of law applicable to them have been developed and applied by judicial decisions of the highest value.

In 1765, the idea occurred to Watt that if the steam were to be condensed in a vessel distinct from the cylinder, it would be practicable to obtain a low temperature of condensation and still keep up the temperature of the cylinder. For that purpose he provided a separate vessel into which the steam from the cylinder entered, which vessel was to be kept cold either by injecting cold water into it or by letting cold water fall over the outside of it, and so a vacuum could be maintained in the separate vessel. Thus the steam which passed over from the cylinder would be condensed, the pressure in the cylinder would be as low as the pressure in the condenser, and the temperature of the metal of the cylinder and piston would be kept up, since no cold injection water would come in contact with them.

On putting the apparatus to a test, it operated as was expected; and, to maintain the vacuum in the separate condenser, Watt added an air pump to remove the condensed steam and injection water, with any air that might gather in the condenser.

He added several subsidiary inventions, such as more tightly packing the piston, closing the upper end of the cylinder, inclosing the piston with a steam-tight stuffing box on top of the cylinder, causing steam instead of air to press on top of the piston, casing the cylinder in a non-conducting material, and introducing a steam jacket between the cylinder and an outer shell. All these features were specified in his first patent, which was obtained in January, 1769.

By an act of Parliament passed in 1775, that patent was continued for 25 years, and Watt, in connection with Matthew Boulton, who owned some engineering works at Birmingham, entered upon the manufacture of steam engines. At first the only application of the engine was to pump water from mines, but Watt soon made other inventions to fit the engine for other uses, and took out further patents in 1781, 1782 and 1784. These inventions covered the method of converting the reciprocating motion of the piston into a rotary motion, so that ordinary machinery could be driven, making the engine double acting by putting both ends of the cylinder in communication, alternately, with the boiler and the condenser, instead of only one end, introducing the system of the expansive working of the steam, instead of admitting it through the whole stroke of the piston, and the well known parallel motion.

Watt's principal patent was sustained by the courts of England, and he enjoyed the fruits of it until it expired in the year 1800. To his great invention we owe the development of the steam engine as used now for traffic and transportation by water and land; for, without it, there could be no practical or efficient steam engine.

The statutes which now regulate the granting of patents in England are those of August 25, 1883 (46 and 47 *Vict. ch.* 57), and December 24, 1888 (51 and 52 *Vict. ch.* 50). It is not necessary that a person should be a British subject to apply for a patent. The application must state that the applicant is in possession of an invention of which he claims to be the true and first inventor. The word "inventor" in these statutes covers an introducer. It is declared by the act of 1883 that the word "inventor" means "any manner of new manufacture, the subject of letters patent and grant of privilege," within section 6 of the act of 21 James I., chapter 3, and includes an alleged invention. There must be either a provisional or a complete specification. If there is only a provisional specification, there must be a complete specification within nine months after the application. There is a limited examination which extends only to an inquiry whether the nature of the invention has been fairly described, and whether the application, specification, and drawings, if any, are in due form, and whether the title sufficiently indicates the subject matter of the invention. The acceptance of the complete specification is to be advertised, and any person may, within two months thereafter, give notice at the Patent Office that he opposes the grant of the patent on the ground that the applicant obtained the invention from him or from a person of whom he is the legal representative, or on the ground that the invention was patented in England on an application of prior date, or on the ground that the complete specification describes or claims an invention other than that described in the provisional specification, and that such other invention forms the subject of an application made by the opponent in the interval between the making of the two specifications. The patent is to be granted for fourteen years, but is to cease if certain fees are not paid within specified times. Disclaimers and amendments of specifications are provided for, but no amendment is allowable which would make the specification, as amended, claim an invention substantially larger than or substantially different from the invention claimed by the specification as it stood before amendment. At least six months before the time limited for the expiration of the patent, the patentee may apply for an extension, which may be granted, on a favorable report from the judicial committee of the Privy Council, for a further term not exceeding 7, or, in exceptional cases, 14 years, and a patent may be vacated by a court on certain specified grounds.

Let us pass now to the patent statutes of the United States.

The Constitution, in article 1, section 8, declares that the Congress shall have power to promote the progress of science and useful arts by securing, for limited times, to inventors the exclusive right to their discoveries.

The first act of Congress on the subject was that of April 10, 1790, entitled "An act to promote the progress of useful arts." This provided for the granting of a patent to the inventor or discoverer of any "useful art, manufacture, engine, machine or device, or any improvement therein, not before known or used." A written specification with drawings, and, if admissible, a model, was required. No examination as to the novelty of the invention was provided for. On an application made to a judge of a district court within one year after the grant of a patent, if it was obtained surreptitiously or upon false suggestion, or if it should appear that the patentee was not the first or true inventor or discoverer, the judge might repeal the patent.

Further acts in regard to patents were passed in 1793, 1794, 1800 and 1832.

On July 4, 1836, an act was passed reorganizing the patent system and repealing all prior acts. By that act patents were to be granted for fourteen years, with the privilege of an extension by the Commissioner, in a proper case, for seven years more. It was required that the applicant should have discovered or invented a new and useful art, machine, manufacture, or a composition of matter, or a new and useful improvement thereon, not known or used by others before his discovery or invention, and not, at the time of the application, in public use or on sale, with his consent or allowance, as the inventor or discoverer.

He was required to deliver a written description of his invention or discovery, and of the manner and process of making, constructing, using, and compounding the same, in such full, clear and exact terms, avoiding unnecessary prolixity, as to enable any person skilled in the art or science to which it appertained, or with which it was most nearly connected, to make, construct, compound, and use the same; and in case of a machine, to explain fully the principle and the several modes in which he had contemplated the application of that principle or character by which it might be distinguished from other inventions; and particularly to specify and point out the part, improvement, or combination which he claimed as his own invention or discovery. Drawings were provided for, and specimens of ingredients of a composition of matter, and a model of machinery, were admissible. A system of examination was instituted, and the patent was to issue if it should not appear to the commissioner that the alleged invention or discovery had been invented or discovered by any other person in this country prior to the alleged invention or discovery by the applicant, or that it had been patented, or described in any printed publication, in this or any foreign country, or had been in public use or on sale with the applicant's consent or allowance, prior to the application, and if the Commissioner should deem it to be sufficiently useful and important. On the refusal of a patent, an appeal was provided for to a board of three examiners. An interference with another pending application, or with an unexpired patent, could be declared, with an appeal to a like board. In case a patent should be inoperative or invalid, by reason of a defective or insufficient description or specification, or by reason of the patentee claiming in the specification as his own invention more than he should have a right to claim as new, if the error arose by inadvertency, accident or mistake, and without any fraudulent or deceptive intention, the Commissioner, on the surrender of the patent, could cause a new patent to be issued to the inventor for the same invention, for the residue of the period then unexpired for which the original patent was granted, in accordance with the patentee's corrected description and specification.

This was called "a reissue." Provision was made for special defenses in actions for damages for infringement, and for giving to the plantiff thirty days' notice before the trial, of the defense of prior use; also for a remedy by bill in equity in the case of two interfering patents, or of the refusal to grant a patent on the ground of its interference with a previous unexpired patent. Equity jurisdiction by the circuit courts of the United States was created, with the power of granting injunctions against infringement. An extension of a patent for seven years was provided for, on its appearing that the patentee, without neglect or fault on his part, has failed to obtain reasonable remuneration.

The foregoing features of the patent system were substantially re-enacted in the act of July 8, 1870, the provisions of which are embodied in the Revised Statutes; but by statute a patent is now granted for only 17 years, and no provision is made for an extension.

In the administration of the patent laws by the courts of the United States, the proper rights of inventors have been firmly maintained, while the abuses which crept in, in consequence of improper reissues of patents, have been corrected. Patents for important and meritorious inventions have been sustained, notably in the case of Morse's telegraph, which was held valid in the case of *O'Reilly v. Morse* (15 *Howard*, 62), the opinion being delivered by Chief Justice Taney.

Samuel F. B. Morse was a historical painter, and had gone to Europe in 1829 to perfect himself in his art. In October, 1832, on board the packet ship Sully, on her passage from Havre, in France, to New York, he conceived the invention which he afterward patented. He persevered in his invention, and by the forepart of the year 1836 he had constructed an instrument which marked down intelligibly telegraphic signs, and demonstrated by actual operation its capacity to accomplish his purpose. Further experiments were made, and in the latter part of September, 1837, a caveat was drawn up and in the following month was filed in the Patent Office.

In February, 1838, a new instrument was exhibited by Professor Morse in the Franklin Institute, at Philadelphia, where it operated with success through a circuit of ten miles of wire; and a committee of the Institute made a report of its success. It was then removed to the city of Washington, and publicly exhibited in the hall of the House of Representatives. On the 3d of March, 1843, Congress appropriated $30,000 to test the capacity and usefulness of the telegraph, by constructing a line under the superintendence of Professor Morse, between the cities of Washington and Baltimore, which was done in the year 1844. The United States patent having been granted to him on June 20, 1840, it was reissued in January, 1846, and came before the Supreme Court of the United States at its December term, 1853. It was sustained after a vigorous opposition.

The principle on which the patent laws are based is to give an inventor an exclusive right, for a limited time, in consideration of his fully disclosing his invention, so that it may be made and used by the public after the limited term shall have expired. Under this stimulus there has come into existence the brilliant succession of inventions which have contributed so greatly to the progress of science and the arts and to the material welfare of nations and individuals. In this career our own country has played no small part, and it is quite certain that in the future American inventors will do their full share toward illustrating the beneficent operation of the patent laws, and that when a hundred years hence there shall be another centennial celebration like the one through which we are now passing, there will have occurred no diminution of the importance and value of American inventions.

THE TENDENCY OF TRADES UNIONS.*

By HERBERT SPENCER.

OF the many ways in which common sense inferences about social affairs are flatly contradicted by events (as when measures taken to suppress a book cause increased circulation of it, or as when attempts to prevent usurious rates of interest make the terms harder for the borrower, or as when there is greater difficulty in getting things at the places of production than elsewhere), one of the most curious is the way in which the more things improve, the louder become the exclamations about their badness.

In days when the people were without any political power, their subjection was rarely complained of; but after free institutions had so far advanced in England that our political arrangements were envied by Continental peoples, the denunciations of aristocratic rule grew gradually stronger, until there came a great widening of the franchise, soon followed by complaints that things were going wrong for want of still further widening. If we trace up the treatment of women from the days of savagedom, when they bore all the burdens and after the men had eaten received such food as remained, up through the middle ages, when they served the men at their meals, to our own day, when throughout on social arrangements the claims of women are always put first, we see that along with the worst treatment there went the least apparent consciousness that the treatment was bad; while now, that they are better treated than ever before, the proclaiming of their grievances daily strengthens, the loudest outcries coming from "the paradise of women," America. A century ago, when scarcely a man could be found who was not occasionally intoxicated, and when inability to take one or two bottles of wine brought contempt, no agitation arose against the vice of drunkenness; but now that, in the course of fifty years, the voluntary efforts of temperance societies, joined with more general causes, have produced comparative sobriety, there are vociferous demands for laws to prevent the ruinous effects of the liquor traffic. Similar again with education. A few generations back ability to read and write was practically limited to the upper and middle classes, and the suggestion that the rudiments of culture should be given to laborers was never made, or, if made, ridiculed; but when, in the days of our grandfathers, the Sunday-school system, initiated by a few philanthropists, began to spread and was followed by the establishment of day schools, with the result that among the masses those who could read and write were no longer the exceptions, and the demand for cheap literature rapidly increased, there began the cry that the people were perishing for lack of knowledge, and that the State must not simply educate them, but must force education upon them.

And so it is, too, with the general state of the population in respect to food, clothing, shelter and the appliances of life. Leaving out of the comparison early barbaric states, there has been a conspicuous progress from the time when most rustics lived on barley bread, rye bread and oatmeal, down to our own time, when the consumption of white wheaten bread is universal; from the days when coarse jackets reaching to the knees left the legs bare, down to the present day, when laboring people, like their employers, have the whole body covered by two or more layers of clothing; from the old era of single-roomed huts without chimneys, or from the fifteenth century, when even an ordinary gentleman's house was commonly without wainscot or plaster on its walls, down to the present century, when every cottage has more rooms than one and the houses of artisans usually have several, while all have fireplaces, chimneys, and glazed windows, accompanied mostly by paper-hangings and painted doors; there has been, I say, a conspicuous progress in the condition of the people. And this progress has been still more marked within our own time. Any one who can look back sixty years, when the amount of pauperism was far greater than now and beggars abundant, is struck by the comparative size and finish of the new houses occupied by operatives; by the better dress of workmen, who wear broadcloth on Sundays, and that of servant girls, who vie with their mistresses; by the higher standard of living which leads to a great demand for the best qualities of food by working people; all results of the double change to higher wages and cheaper commodities, and a distribution of taxes which has relieved the lower classes at the expense of the upper classes. He is struck, too, by the contrast between the small space which popular welfare then occupied in public attention and the large space it now occupies, with the result that outside and inside Parliament, plans to benefit the millions form the leading topics, and every one having means is expected to join in some philanthropic effort. Yet while elevation,

* Introduction to "A Plea for Liberty, an argument against Socialism and Socialistic Legislation," by Thomas Mackay. London, John Murray; New York, Frederick M. Stokes & Co.

mental and physical, of the masses is going on far more rapidly than ever before; while the lowering of the death-rate proves that the average life is less trying, there swells louder and louder the cry that the evils are so great that nothing short of a social revolution can cure them. In presence of obvious improvements, joined with that increase of longevity which even alone yields conclusive proof of general amelioration, it is proclaimed, with increasing vehemence, that things are so bad that society must be pulled to pieces and reorganized on another plan. In this case, then, as in the previous cases instanced, in proportion as the evil decreases, the denunciation of it increases; and as fast as natural causes are shown to be powerful, there grows up the belief that they are powerless.

Not that the evils to be remedied are small. Let no one suppose that by emphazing the above paradox I wish to make light of the sufferings which most men have to bear. The fates of the great majority have ever been, and doubtless are, so sad that it is painful to think of them. Unquestionably the existing type of social organization is one which none who cares for his kind can contemplate with satisfaction; and unquestionably men's activities accompanying this type are far from being admirable. The strong divisions of rank and the immense inequalities of means are at variance with that ideal of human relations on which the sympathetic imagination likes to dwell; and the average conduct, under the pressure and excitement of social life as at present carried on, is in sundry respects repulsive. Though the many who revile competition strangely ignore the enormous benefits resulting from it; though they forget that most of the appliances and products distinguishing civilization from savagery, and making possible the maintenance of a large population on a small area, have been developed by the struggle for existence; though they disregard the fact that while every man, as producer, suffers from the underbidding of competitors, yet, as consumer, he is immensely advantaged by the cheapening of all he has to buy; though they persist in dwelling on the evils of competition, saying nothing of its benefits, yet it is not to be denied that the evils are great, and form a large set-off from the benefits. The system under which we at present live fosters dishonesty and lying. It prompts adulterations of countless kinds; it is answerable for the cheap imitations which eventually in many cases thrust the genuine articles out of the market; it leads to the use of short weights and false measures; it introduces bribery, which vitiates most trading relations, from those of the manufacturer and buyer down to those of the shopkeeper and servant; it encourages deception to such an extent that an assistant who cannot tell a falsehood with a good face is blamed; and often it gives the conscientious trader the choice between adopting the malpractices of his competitors or greatly injuring his creditors by bankruptcy. Moreover, the extensive frauds, common throughout the commercial world and daily exposed in law courts and newspapers, are largely due to the pressure under which competition places the higher industrial classes; and are otherwise due to that lavish expenditure which, as implying success in the commercial struggle, brings honor. With these minor evils must be joined the major one, that the distribution achieved by the system gives to those who regulate and superintend a share of the total produce which bears too large a ratio to the share it gives to the actual workers. Let it not be thought, then, that in saying what I have said above I underestimate those vices of our competitive system which, thirty years ago, I described and denounced. But it is not a question of absolute evils; it is a question of relative evils; whether evils at present suffered are or are not less than the evils which would be suffered under another system; whether efforts for mitigation along the lines thus far followed are not more likely to succeed than efforts along utterly different lines.

This is the question here to be considered. I must be excused for first of all setting forth sundry truths which are to some, at any rate, tolerably familiar, before proceeding to draw inferences which are not so familiar.

Speaking broadly, every man works that he may avoid suffering. Here remembrance of the pangs of hunger prompts him; and there he is prompted by the sight of the slave driver's lash. His immediate dread may be the punishment which physical circumstances will inflict, or may be punishment inflicted by human agency. He must have a master; but the master may be nature or may be a fellow man. When he is under the impersonal coercion of nature, we say that he is free; and when he is under the personal coercion of some one above him, we call him, according to the degree of his dependence, a slave, a serf or a vassal. Of course I omit the small minority who inherit means: an incidental, and not a necessary, social element. I speak only of the vast majority, both cultured and uncultured, who maintain themselves by labor, bodily or mental, and must either exert themselves of their own unconstrained wills, prompted only by thoughts of naturally resulting evils or benefits, or must exert themselves with constrained wills, prompted by thoughts of evils and benefits artificially resulting.

Men may work together in a society under either of these two forms of control; forms which, though in many cases mingled, are essentially contrasted. Using the word co-operation in its wide sense and not in that restricted sense now commonly given to it, we may say that social life must be carried on by either voluntary co-operation, or compulsory co-operation; or, to use Sir Henry Maine's words, the system must be that of contract or that of status—that in which the individual is left to do the best he can by his spontaneous efforts, and get success or failure according to his efficiency, and that in which he has his appointed place, works under coercive rule, and has his apportioned share of food, clothing and shelter.

The system of voluntary co-operation is that by which, in civilized societies, industry is now everywhere carried on. Under a simple form we have it on every farm, where the laborers, paid by the farmer himself and taking orders directly from him, are free to stay or go as they please. And of its more complex form an example is yielded by every manufacturing concern in which, under partners, come clerks and managers, and under these timekeepers and overlookers, and under these operatives of different grades. In each of these cases there is an obvious working together, or co-operation of employer and employed, to obtain in one case a crop and in the other case a manufactured stock. And then, at the same time, there is a far more extensive, though unconscious, co-operation with other workers of all grades throughout society. For, while these particular employers and employed are severally occupied with their special kinds of work, other employers and employed are making other things needed for the carrying on of their lives as well as the lives of all others. This voluntary co-operation, from its simplest to its most complex forms, has the common trait that those concerned work together by consent. There is no one to force terms or to force acceptance. It is perfectly true that in many cases an employer may give, or an employe may accept, with reluctance; circumstances he says compel him. But what are the circumstances? In the one case there are goods ordered, or a contract entered into, which he cannot supply or execute without yielding; and in the other case he submits to a wage less than he likes because otherwise he will have no money wherewith to procure food and warmth. The general formula is not, "Do this, or I will make you;" but it is, "Do this, or leave your place and take the consequences."

On the other hand, compulsory co-operation is exemplified by an army—no so much by our own army, the service in which is under agreement for a specified period, but in a Continental army, raised by conscription. Here in time of peace the daily duties—cleaning, parade, drill, sentry work and the rest—and in time of war the various actions of the camp and the battle field, are done under command, without room for any exercise of choice. Up from the private soldier through the non-commissioned officers and the half dozen or more grades of commissioned officers, the universal law is absolute obedience from the grade below to the grade above. The sphere of individual will is such only as is allowed by the will of the superior. Breaches of subordination are, according to their gravity, dealt with by deprivation of leave, extra drill, imprisonment, flogging, and, in the last resort, shooting. Instead of the understanding that there must be obedience in respect of specified duties under pain of dismissal, the understanding now is, "Obey in everything ordered under penalty of inflicted suffering and perhaps death."

This form of co-operation, still exemplified in an army, has in days gone by been the form of co-operation throughout the civil population. Everywhere, and at all times, chronic war generates a militant type of structure, not in the body of soldiers only but throughout the community at large. Practically, while the conflict between societies is actively going on, and fighting is regarded as the only manly occupation, the society is the quiescent army and the army the mobilized society; that part which does not take part in battle, composed of slaves, serfs, women, etc., constituting the commissariat. Naturally, therefore, throughout the mass of inferior individuals constituting the commissariat, there is maintained a system of discipline identical in nature if less elaborate. The fighting body being, under such conditions, the ruling body, and the rest of the community being incapable of resistance, those who control the fighting body will, of course, impose their control upon the non-fighting body; and the regime of coercion will be applied to it with such modifications only as the different circumstances involve. Prisoners of war become slaves. Those who were free cultivators before the conquest of their country, become serfs attached to the soil. Petty chiefs become subject to superior chiefs; these smaller lords become vassals to over-lords; and so on up to the highest; the social ranks and powers being of like essential nature with the ranks and powers throughout the military organization. And while for the slaves compulsory co-operation is the unqualified system, a co-operation which is in part compulsory is the system that pervades all grades above. Each man's oath of fealty to his suzerain takes the form, "I am your man."

Throughout Europe, and especially in our own country, this system of compulsory co-operation gradually relaxed in rigor, while the system of voluntary co-operation step by step replaced it. As fast as war ceased to be the business of life, the social structure produced by war and appropriate to it slowly became qualified by the social structure produced by industrial life and appropriate to it. In proportion as a decreasing part of the community was devoted to offensive and defensive activities, an increasing part became devoted to production and distribution. Growing more numerous, more powerful, and taking refuge in towns where it was less under the power of the militant class, this industrial population carried on its life under the system of voluntary co-operation. Though municipal governments and guild regulations, partially pervaded by ideas and usages derived from the militant type of society, were in some degree coercive, yet production and distribution were in the main carried on under agreement—alike between buyers and sellers and between masters and workmen. As fast as these social relations and forms of activity became dominant in urban populations, they influenced the whole community; compulsory co-operation lapsed more and more, through money commutation for services, military and civil; while divisions of rank became less rigid and class power diminished. Until at length restraints exercised by incorporated trades have fallen into desuetude, as well as the rule of rank over rank, voluntary co-operation became the universal principle. Purchase and sale became the law for all kinds of services, as well as for all kinds of commodities.

The restlessness generated by pressure against the conditions of existence perpetually prompts the desire to try a new position. Every one knows how long-continued rest in one attitude becomes wearisome; every one has found how even the best easy chair, at first rejoiced in, becomes after many hours intolerable; and change to a hard seat, previously occupied and rejected, seems for a time to be a great relief. It is the same with incorporated humanity. Having by long struggles emancipated itself from the hard discipline of the ancient regime, and having discovered that the new regime into which it has grown, though relatively easy, is not without stresses and pains, its impatience with these prompts the wish to try another system; which other system is in principle, if not in appearance, the same as that which during the past generations was escaped from with much rejoicing.

For as fast as the regime of contract is discarded, the regime of status is of necessity adopted. As fast as voluntary co-operation is abandoned, compulsory co-operation must be substituted. Some kind of organization labor must have; and if it is not that which arises by agreement under free competition, it must be that which is imposed by authority. Unlike in appearance and names as it may be to the old order of slaves and serfs, working under masters who were coerced by barons, who were themselves vassals of dukes or kings, the new order wished for, constituted by workers under foremen of small groups, overlooked by superintendents, who are subject to higher local managers, who are controlled by superiors of districts, themselves under a central government, must be essentially the same in principle. In the one case, as in the other, there must be established grades, and enforced subordination of each grade to the grades above. This is a truth which the Communist or the Socialist does not dwell upon. Angry with the existing system under which each of us takes care of himself, while all of us see that each has fair play, he thinks how much better it would be for all of us to take care of each of us; and he refrains from thinking of the machinery by which this is to be done. Inevitably, if each is to be cared for by all, then the embodied all must get the means—the necessaries of life. What it gives to each must be taken from the accumulated contributions; and it must therefore require from each his proportion—must tell him how much he has to give to the general stock in the shape of production, that he may have so much in the shape of sustentation. Hence, before he can be provided for, he must put himself under orders, and obey those who say what he shall do, and at what hours, and where; and who shall give him his share of food, clothing and shelter. If competition is excluded, and with it buying and selling, there can be no voluntary exchange of so much labor for so much produce; but there must be apportionment of the one to the other by appointed officers. This apportionment must be enforced. Without alternative the work must be done, and without alternative the benefit, whatever it may be, must be accepted. For the worker may not leave his place at will and offer himself elsewhere. Under such a system he cannot be accepted elsewhere, save by order of the authorities. And it is manifest that a standing order would forbid employment in one place of an insubordinate member from another place. The system could not be worked if the workers were severally allowed to go or come as they pleased. With corporals and sergeants under them, the captains of industry must carry out the orders of their colonels, and these of their generals, up to the council of the commander-in-chief, and obedience must be required throughout the industrial army as throughout a fighting army. "Do your prescribed duties and take your apportioned rations," must be the rule of the one as of the other. "Well, be it so," replies the Socialist. "The workers will appoint their own officers, and these will always be subject to criticisms of the mass they regulate. Being thus in fear of public opinion, they will be sure to act judiciously and fairly; or when they do not, will be deposed by the popular vote, local or general. Where will be the grievance of being under superiors, when the superiors themselves are under democratic control?" And in this attractive vision the Socialist has full belief.

Iron and brass are simpler things than flesh and blood, and dead wood than living nerve; and a machine constructed of the one works in more definite ways than an organism constructed of the other—especially when the machine is worked by the inorganic forces of steam or water, while the organism is worked by the forces of living nerve centers. Manifestly, then, the ways in which the machine will work are much more readily calculable than the ways in which the organism will work. Yet in how few cases does the inventor foresee rightly the actions of his new apparatus. Read the patent list, and it will be found that not more than one device in fifty turns out to be of any service. Plausible as his scheme seemed to the inventor, one or other hitch prevents the intended operation and brings out a widely different result from that which he wished.

What then shall we say of these schemes which have to do, not with the dead matters and forces, but with complex living organisms working in ways less readily foreseen, and which involve the co-operation of multitudes of such organisms? Even the units out of which this rearranged body politic is to be formed are often incomprehensible. Every one is from time to time surprised by others' behavior, and even by the deeds of relatives who are best known to him. Seeing, then, how uncertainly any one can foresee the actions of an individual, how can he with any certainty foresee the operation of a social structure? He proceeds on the assumption that all concerned will judge rightly and act fairly—will think as they ought to think, and act as they ought to act; and he assumes this regardless of the daily experiences which show him that men do neither the one nor the other, and forgetting that the complaints he makes against the existing system show his belief to be that men have neither the wisdom nor the rectitude which his plan requires them to have.

Paper constitutions raise smiles on the faces of those who have observed their results; and paper social systems similarly affect those who have contemplated the available evidence. How little the men who wrought the French revolution, and were chiefly concerned in setting up the new governmental apparatus, dreamed that one of the early actions of this apparatus would be to behead them all! How little the men who drew up the American Declaration of Independence and framed the Republic anticipated that, after some generations, the legislature would lapse into the hands of wire pullers; that its doings would turn upon the contests of office seekers, that political action would be everywhere vitiated by the intrusion of a foreign element holding the balance between parties, that electors, instead of judging for themselves, would habitually be led to the polls in thousands by their "bosses," and that respectable men would be driven out of public life by the insults and slanders of professional politicians. Nor were there better provisions in those who gave constitutions to the various other states of the New World, in which unnumbered revolutions have shown with wonderful persistence the contrasts between the expected results of political systems and the achieved results. It has been no less thus with proposed systems of social reorganization, so far as they have been

tried. Save where celibacy has been insisted on, their history has been everywhere one of disaster, ending with the history of Cabet's Icarian colony lately given by one of its members, Mme. Fleury Robinson, in *The Open Court*—a history of splittings, resplittings, re-resplittings, accompanied by numerous individual secessions and final dissolution. And for the failure of such social schemes, as for the failure of the political schemes, there has been one general cause.

Metamorphosis is the universal law, exemplified throughout the heavens and on the earth, especially throughout the organic world, and above all in the animal division of it. No creature, save the simplest and most minute, commences its existence in a form like that which it eventually assumes, and in most cases the unlikeness is great—so great that kinship between the first and the last forms would be incredible were it not daily demonstrated in every poultry yard and every garden. More than this is true. The changes of form are often several, each of them being an apparently complete transformation—egg, larva, pupa, imago, for example. And this universal metamorphosis, displayed alike in the development of a planet and of every seed which germinates on its surface, holds also of societies, whether taken as wholes or in their separate institutions. No one of them ends as it begins, and the difference between its original structure and its ultimate structure is such that, at the outset, change of the one into the other would have seemed incredible. In the rudest tribe the chief, obeyed as leader in war, loses his distinctive position when the fighting is over, and even where continued warfare has produced permanent chieftainship, the chief building his own hut, getting his own food, making his own implements, differs from others only by his predominant influence. There is no sign that in course of time, by conquests and unions of tribes and consolidations of clusters so formed with other such clusters, until a nation has been produced, there will originate from the primitive chief one who, as czar or emperor, surrounded with pomp and ceremony, has despotic power over scores of millions, exercised through hundreds of thousands of soldiers and hundreds of thousands of officials. When the early Christian missionaries, having humble externals and passing self-denying lives, spread over pagan Europe, preaching forgiveness of injuries and the returning of good for evil, no one dreamed that in course of time their representatives would form a vast hierarchy, possessing everywhere a large part of the land, distinguished by the haughtiness of its members, grade above grade, ruled by military bishops, who led their retainers to battle, and headed by a pope exercising supreme power over kings. So, too, has it been with that very industrial system which many are now so eager to replace. In its original form there was no prophecy of the factory system or kindred organizations of workers. Differing from them only as being the head of his house, the master worked along with his apprentices and a journeyman or two, sharing with them his table and accommodation and himself selling their joint produce. Only with industrial growth did there come employment of a larger number of assistants and a relinquishment on the part of the master of all other business than that of superintendence. And only in the course of recent times did there evolve the organizations under which the labors of hundreds and thousands of men receiving wages are regulated by various orders of paid officials under a single or multiple head. These originally small, semi-socialistic groups of producers, like the compound families or house communities of early ages, slowly dissolved because they could not hold their ground; the larger establishments, with better subdivision of labor, succeeded because they ministered to the wants of society more effectually. But we need not go back through the centuries to trace transformations sufficiently great and unexpected. On the day when £30,000 a year in aid of education was voted as an experiment the name of idiot would have been given to an opponent who prophesied that in fifty years the sum spent through imperial taxes and local rates would amount to £10,000,000, or who said that the aid to education would be followed by aids to feeding and clothing, or who said that parents and children, alike deprived of all option, would, even if starving, be compelled by fine or imprisonment to conform and receive that which, with papal assumption, the state calls education. No one, I say, would have dreamed that out of so innocent-looking a germ would have so quickly evolved this tyrannical system, tamely submitted to by people who fancy themselves free.

Thus in social arrangements, as in all other things, change is inevitable. It is foolish to suppose that new institutions set up will long retain the character given them by those who set them up. Rapidly or slowly they will be transformed into institutions unlike those intended, so unlike as even to be unrecognizable by their devisers. And what in the case before us will be the metamorphosis? The answer pointed to by instances above given and warranted by various analogies is manifest.

A cardinal trait in all advancing organizations is the development of the regulative apparatus. If the parts of a whole are to act together, there must be appliances by which their actions are directed, and in proportion as the whole is large and complex and has many requirements to be met by many agencies, the directive apparatus must be extensive, elaborate and powerful. That it is thus with individual organisms needs no saying, and that it must be thus with social organisms is obvious. Beyond the regulative apparatus, such as in our own society is required for carrying on national defense and maintaining public order and personal safety, there must, under the régime of Socialism, be a regulative apparatus everywhere controlling all kinds of production and distribution and everywhere apportioning the shares of products of each kind required for each locality, each working establishment, each individual. Under our existing voluntary co-operation, with its free contracts and its competition, production and distribution need no official oversight. Demand and supply, and the desire of each man to gain a living by supplying the needs of his fellows, spontaneously evolve that wonderful system whereby a great city has its food daily brought round to all doors or stored at adjacent shops; has clothing for its citizens everywhere at hand in multitudinous varieties; has its houses and furniture and fuel ready made or stocked in each locality; and has mental pabulum from half-penny papers, hourly hawked around, to weekly shoals of novels, and less abundant books of instruction, furnished without stint for small payments. And throughout the kingdom, production as well as distribution is similarly carried on with the smallest amount of superintendence which proves efficient; while the quantities of the numerous commodities required daily in each locality are adjusted without any other agency than the pursuit of profit. Suppose now that this industrial régime of willinghood, acting spontaneously, is replaced by a régime of industrial obedience, enforced by public officials. Imagine the vast administration required for that distribution of all commodities to all people in every city, town and village which is now effected by traders! Imagine, again, the still more vast administration required for doing all that farmers, manufacturers and merchants do; having not only its various orders of local superintendents, but its sub-centers and chief centers needed for apportioning the quantities of each thing everywhere needed, and the adjustment of them to the requisite times. Then add the staffs wanted for working mines, railways, roads, canals; the staffs required for conducting the importing and exporting businesses and the administration of mercantile shipping; the staffs required for supplying towns not only with water and gas, but with locomotion by tramways, omnibuses and other vehicles, and for the distribution of power, electric and other. Join with these the existing postal, telegraphic and telephonic administrations, and finally those of the police and army, by which the dictates of this immense consolidated regulative system are to be everywhere enforced. Imagine all this, and then ask what will be the position of the actual workers. Already on the Continent, where governmental organizations are more elaborate and coercive than here, there are chronic complaints of the tyranny of bureaucracies—the hauteur and brutality of their members. What will these become when not only the more public actions of citizens are controlled, but there is added this far more extensive control of all their respective daily duties? What will happen when the various divisions of this vast army of officials, united by interests common to officialism—the interests of the regulators versus those of the regulated—have at their command whatever force is needful to suppress insubordination and act as "saviors of society"? Where will be the actual diggers and miners and smelters and weavers, when those who order and superintend, everywhere arranged class above class, have come, after some generations, to intermarry, with those of kindred grades, under feelings such as are operative in existing classes; and when there have been so produced a series of castes rising in superiority; and when all these, having everything in their own power, have arranged modes of living for their own advantage: eventually forming a new aristocracy far more elaborate and better organized than the old? How will the individual worker fare if he is dissatisfied with his treatment—thinks that he has not an adequate share of the products, or has more to do than can rightly be demanded, or wishes to undertake a function for which he feels himself fitted, but which is not thought proper for him by his superiors, or desires to make an independent career for himself? This dissatisfied unit in the immense machine will be told he must submit or go. The mildest penalty for disobedience will be industrial excommunication. And if an international organization of labor is formed as proposed, exclusion in one country will mean exclusion in all others—industrial excommunication will mean starvation.

That things must take this course is a conclusion reached not by deduction only, nor only by induction from those experiences of the past instanced above, nor only from consideration of the analogies furnished by organisms of all orders; but it is reached also by observation of cases daily under our eyes. The truth that the regulative structure always tends to increase in power is illustrated by every established body of men. The history of each learned society, or society for other purpose, shows how the staff, permanent or partially permanent, sways the proceedings and determines the actions of the society with but little resistance, even when most members of the society disapprove: the repugnance to anything like a revolutionary step being ordinarily an efficient deterrent. So it is with joint-stock companies—those owning railways for example. The plans of a board of directors are usually authorized with little or no discussion; and if there is any considerable opposition, this is forthwith crushed by an overwhelming number of proxies sent by those who always support the existing administration. Only when the misconduct is extreme does the resistance of shareholders suffice to displace the ruling body. Nor is it otherwise with societies formed of workingmen and having the interests of labor especially at heart—the trades unions. In these, too, the regulative agency becomes all-powerful. Their members, even when they dissent from the policy pursued, habitually yield to the authorities they have set up. As they cannot secede without making enemies of their fellow-workmen, and often losing all chance of employment, they succumb. We are shown, too, by the late congress that already, in the general organization of trades unions so recently formed, there are complaints of "wire-pullers," and "bosses," and "permanent officials." If, then, this supremacy of the regulators is seen in bodies of quite modern origin formed of men who have, in many of the cases instanced, unhindered powers of asserting their independence, what will the supremacy of the regulators become in long established bodies, in bodies which have grown vast and highly organized, and in bodies which, instead of controlling only a small part of the unit's life, control the whole of his life?

Again there will come the rejoinder: "We shall guard against all that. Everybody will be educated; and all, with their eyes constantly wide open to the abuse of power, will be quick to prevent it." The worth of these expectations would be small even could we not indentify the causes which will bring disappointment, for in human affairs the most promising schemes go wrong in ways which no one anticipated. But in this case the going wrong will be necessitated by causes which are conspicuous. The working of institutions is determined by men's characters, and the existing defects in their characters will inevitably bring about the results above indicated. There is no adequate endowment of those sentiments required to prevent the growth of a despotic bureaucracy.

Were it needful to dwell on indirect evidence, much might be made of that furnished by the behavior of the so-called Liberal party—a party which, relinquishing the original conception of a leader as a mouthpiece for a known and accepted policy, thinks itself bound to accept a policy which its leader springs upon it without consent or warning; a party so utterly without the feeling and idea implied by liberalism as not to resent this trampling on the right of private judgment which constitutes the root of liberalism; nay, a party which vilifies as renegade Liberals those of its members who refuse to surrender their independence! But without occupying space with indirect proofs that the mass of men have not the natures required to check the development of tyrannical officialism, it will suffice to contemplate the direct proofs furnished by those classes among whom the socialistic idea most predominates, and who think think themselves most interested in propagating it—the operative classes. These would constitute the great body of the socialistic organization, and their characters would determine its nature. What, then, are their characters as displayed in such organizations as they have already formed.

Instead of the selfishness of the employing classes and the selfishness of competition, we are to have the unselfishness of a mutually aiding system. How far is this unselfishness now shown in the behavior of workingmen to one another? What shall we say to the rules limiting the numbers of new hands admitted into each trade, or to the rules which hinder ascent from inferior classes of workers to superior classes? One does not see in such regulations any of that altruism by which socialism is to be pervaded. Contrariwise, one sees a pursuit of private interests no less keen than among traders. Hence, unless we suppose that men's natures will be suddenly exalted, we must conclude that the pursuit of private interests will sway the doings of all the component classes in a socialistic society.

With passive disregard of others' claims goes active encroachment on them. "Be one of us or we will cut off your means of living," is the usual threat of each trades' union to outsiders of the same trade. While their members insist on their own freedom to combine and fix the rates at which they will work (as they are perfectly justified in doing), the freedom of those who disagree with them is not only denied, but the assertion of it is treated as a crime.

Individuals who maintain their rights to make their own contracts are vilified as "blacklegs" and "traitors," and meet with violence which would be merciless were there no legal penalties and no police. Along with this trampling on the liberties of men of their own class, there goes peremptory dictation to the employing class; not prescribed terms and working arrangements only shall be conformed to, but none save those belonging to their body shall be employed—nay, in some cases there shall be a strike if the employer carries on transactions with trading bodies that give work to non-union men. Here, then, we are variously shown by trades' unions, or at any rate by the newer trades' unions, a determination to impose their regulations without regard to the rights of those who are to be coerced. So complete is the inversion of ideas and sentiments that maintenance of these rights is regarded as vicious and trespass upon them as virtuous.

Along with this aggressiveness in one direction there goes submissiveness in another direction. The coercion of outsiders by unionists is paralleled only by their subjection to their leaders. That they may conquer in the struggle, they surrender their individual liberties and individual judgments, and show no resentment, however dictatorial may be the rule exercised over them. Everywhere we see such subordination that bodies of workmen unanimously leave their work or return to it as their authorities order them. Nor do they resist when taxed all round to support strikers whose acts they may or may not approve, but instead ill-treat recalcitrant members of their body who do not subscribe.

The traits thus shown must be operative in any new social organization, and the question to be asked is—What will result from their operation when they are relieved from all restraints? At present the separate bodies of men displaying them are in the midst of a society partially passive, partially antagonistic; are subject to the criticisms and reprobations of an independent press; and are under the control of law, enforced by police. If in these circumstances these bodies habitually take courses which override individual freedom, what will happen when, instead of being only scattered parts of the community, governed by their separate sets of regulators, they constitute the whole community, governed by a consolidated system of such regulators; when functionaries of all orders, including those who officer the press, form parts of the regulative organization, and when the law is both enacted and administered by this regulative organization? The fanatical adherents of a social theory are capable of taking any measures, no matter how extreme, for carrying out their views, holding, like the merciless priesthoods of past times, that the end justifies the means. And when a general socialistic organization has been established, the vast, ramified and consolidated body of those who direct its activities, using without check whatever coercion seems to them needful in the interests of the system (which will practically become their own interests), will have no hesitation in imposing their rigorous rule over the entire lives of the actual workers; until, eventually, there is developed an official oligarchy, with its various grades, exercising a tyranny more gigantic and more terrible than any which the world has seen.

Let me again repudiate an erroneous inference. Any one who supposes that the foregoing argument implies contentment with things as they are, makes a profound mistake. The present social state is transitional, as past social states have been transitional. There will, I hope and believe, come a future social state differing as much from the present as the present differs from the past with its mailed barons and defenseless serfs. In Social Statics, as well as in the Study of Sociology and in Political Institutions, is clearly shown the desire for an organization more conducive to the happiness of men at large than that which exists. My opposition to Socialism results from the belief that it would stop the progress to such a higher state and bring back a lower state. Nothing but the slow modification of human nature by the discipline of social life can produce permanently advantageous changes.

A fundamental error pervading the thinking of nearly all parties, political and social, is that evils admit of immediate and radical remedies. "If you will but do this, the mischief will be prevented." "Adopt my plan and the suffering will disappear." "The corruption will unquestionably be cured by enforcing this measure." Everywhere one meets with beliefs, expressed or implied, of these kinds. They are all ill-founded. It is possible to remove causes which intensify the evils; it is possible to change the evils from one form into another, and it is possible, and very common, to exacerbate the evils by the efforts made to prevent them; but anything like immediate cure is impossible. In the course of thousands of years mankind have, by multiplication, been forced out of that original savage state in which small numbers supported themselves on wild food, into the civilized state in which the food required for supporting great numbers can be got only by continuous labor. The nature required for this last mode of life is widely different from the nature required for the first; and long-continued pains have to be passed through in remoulding the one into the other. Misery has necessarily to be borne by a constitution out of harmony with its conditions; and a constitution inherited from primitive men is out of harmony with the conditions imposed on existing men. Hence it is impossible to establish forthwith a satisfactory social state. No such nature as that which has filled Europe with millions of armed men, here eager for conquest and there for revenge; no such nature as that which prompts the nations called Christian to vie with one another in filibustering expeditions all over the world, regardless of the claims of aborigines, while their tens of thousands of priests of the religion of love look on approvingly; no such nature as that which, in dealing with weaker races, goes beyond the primitive rule of life for life, and for one life takes many lives; no such nature, I say, can by any device be framed into a harmonious community. The root of all well-ordered social action is a sentiment of justice, which at once insists on personal freedom and is solicitous for the like freedom of others, and there at presents exists but a very inadequate amount of this sentiment.

Hence the need for further long continuance of a social discipline which requires each man to carry on his activities with due regard to the like claims of others to carry on their activities; and which, while it insists that he shall have all the benefits his conduct naturally brings, insists also that he shall not saddle on others the evils his conduct naturally brings, unless they freely undertake to bear them. And hence the belief that endeavors to elude this discipline will not only fail, but will bring worse evils than those to be escaped.

It is not, then, chiefly in the interests of the employing classes that Socialism is to be resisted, but much more in the interests of the employed classes. In one way or other production must be regulated; and the regulators, in the nature of things, must always be a small class as compared with the actual producers. Under voluntary co-operation as at present carried on, the regulators, pursuing their personal interests, take as large share of the produce as they can get; but, as we are daily shown by Trades Union successes, are restrained in the selfish pursuit of their ends. Under that compulsory co-operation which Socialism would necessitate, the regulators, pursuing their personal interests with no less selfishness, could not be met by the combined resistance of free workers; and their power, unchecked as now by refusals to work save on prescribed terms, would grow and ramify and consolidate till it became irresistible. The ultimate result, as I have before pointed out, must be a society like that of ancient Peru, dreadful to contemplate, in which the mass of the people, elaborately regimented in groups of 10, 50, 100, 500 and 1,000, ruled by officers of corresponding grades and tied to their districts, were superintended in their private lives as well as in their industries, and toiled hopelessly for the support of the governmental organization.

THE FIRST OCEAN STEAMER.

By F. L. HAGADORN.

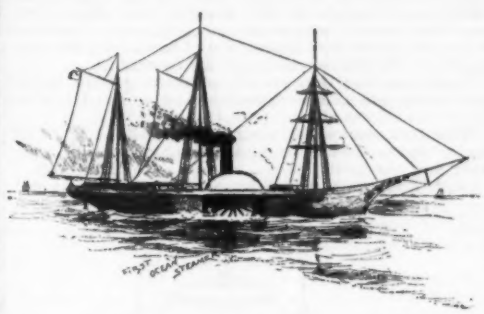
IT is remarkable that after so much has been written and published in regard to early steam navigation (especially ocean navigation, which is of comparatively recent date), it remains to be shown that the first regularly built ocean steamer was constructed on this side of the Atlantic. Waiving all that has been claimed for the voyage of the Savannah, we now find that an American shipbuilder constructed the first sea-going steamer that ever crossed the ocean, propelled wholly by steam. This was called the Royal William, in honor of the "sailor king," who then reigned in England, and the Historical Society of Chicago has her original drawings on file in its archives.

A letter published in the Quebec *Morning Chronicle*, and dated London, September 14, 1833, says: "The steamer Royal William arrived here some days since from Pictou in nineteen days, out of which she had two days' detention to make some alterations in her machinery. The whole distance of the voyage (about 2,500 miles) was performed by steam with the most perfect success."

Mr. James Goudie, having drawn the lines for this vessel, was called upon to superintend her construction, and in the fall of 1830 laid her keel in the yard of Campbell & Black, in the city of Quebec. She was a ship of 1,645 tons burden, somewhat in the style of those running between Scotland and Ireland, but of great strength, in order to encounter the ice of the St. Lawrence, being intended as a packet between Quebec and Halifax, so long as the navigation could be kept open, and to run from Halifax to the West Indies the rest of the year.

Mr. Goudie is still living, and in excellent health and spirits, although he has just entered upon his eighty-third year. In a letter now before me he says: "I proceeded to Quebec in May, 1830, and was engaged to carry out the plans and construction of vessel. She was laid down in the fall of 1830, and completed in 1831. The lateness of the season at which the ship was got ready precluded her from doing much that season. The next year opened up with very poor prospects. Cholera had made its appearance at Quebec, and business was almost entirely suspended. So she was run at a great loss, ultimately being laid up. The following year she was run a few trips at a loss, and it was decided in the month of August, 1833, to send her to London, England, for sale. She arrived out after a prosperous trip of twenty-five days. She was put up for sale, and was finally sold to the Spanish government for £10,000 sterling, having cost in building £19,000, Halifax currency."

I am particular to give this quotation in order to account for the obscurity which has hitherto hung around this enterprise. Men, as a general thing, are not prone to talk much about their unfortunate ventures. If they "pick the flint and try again," it is generally in some new direction. Although the building of this vessel and her performances as a sea-going craft constituted a professional triumph for Mr. Goudie, she did not "pay," and it was not until steam had driven nearly all other propulsion from the ocean that her original promoters seemed anxious to claim any participation in the enterprise—much less to contest with



others the credit of being first to send a veritable ocean steamer across the Atlantic.

I have the original plan, of which the illustration is photographically exact.

The following is a table of her dimensions:

	Feet.
Length of deck	169
Length of keel	159
Extreme breadth	47
Depth of hold	19
Rake of post	2
Rake of stern	13
Draught of water	14
Burden	1,645 tons.

It will be seen by the curved lines abaft her paddle boxes that she was provided with cavities or depressions upon each side, for the protection of her wheels. This was a bold innovation, and there may be those who would regard it as unnecessary; but it has recently been patented, and is now likely to become an important factor in naval architecture, especially for canal navigation, or where ice is to be encountered. It is claimed that by putting two small propellers near the bow of a vessel, instead of a single large one at the stern, she may be handled and directed with marvelous facility. But the propellers must be placed in these recesses, and if so, there may be four or six of them, or even more, and the speed of the ship be correspondingly increased.

I am aware that the little steamer Phœnix had made a trip from the Hudson around to the Delaware by sea in 1807; and twelve years afterward the Savannah made a voyage from Savannah, Georgia, to Russia, via England, returning to New York direct from St. Petersburg in twenty-six days.

These were not ocean steamers, however, as we understand the term. The Phœnix was a small river steamboat, built in New York, where she was not permitted to navigate the waters on account of the monopoly secured by Fulton and his associates. The Savannah was a regular-built full-rigged sailing ship, having only an auxiliary engine on board, and sidewheels that could be unshipped and hoisted on deck in stormy weather. On her return to New York, her engines were taken out, her side wheels unshipped, and she resumed her place in the line as a regular Savannah packet.

On the other hand, Goudie's ship was built expressly for an ocean steamer, and was the first of her class to cross the Atlantic.

It was not until five years and three months afterward that the Sirius, a little vessel of seven hundred tons and two hundred and fifty horse power, and her consort, the Great Western, of thirteen hundred and forty tons and four hundred and fifty horse power, arrived in New York harbor on the same day (April 23, 1838); the Sirius, which sailed from Cork, April 4, arriving in the morning, and the Great Western, which sailed from Bristol, April 8, arriving in the afternoon. But Goudie's steamer not only antedated these by several years, but was more than three hundred tons greater burden than the larger of them. These were all side-wheel steamers, as was also Ericsson's Great Eastern. But Ericsson was at the same time experimenting with the screw propeller, as Colonel Stevens had before him, so long ago as 1804; and since that period, comparatively few ocean steamers have employed the paddle wheel.

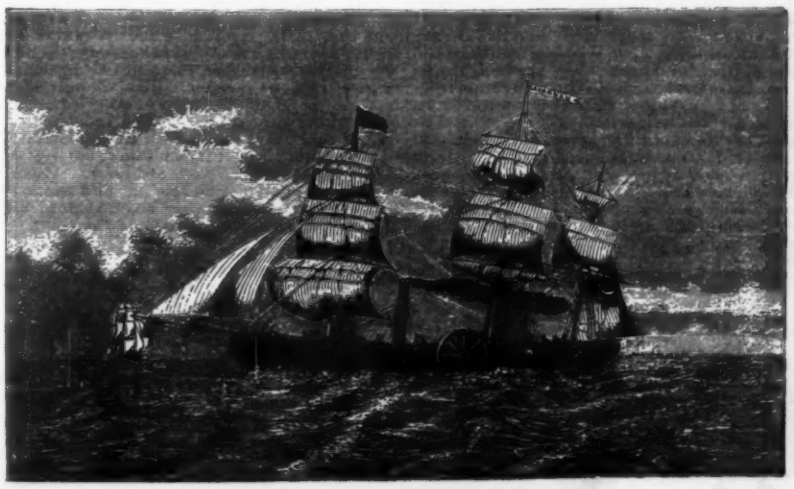
When the Royal William was transferred to the Spanish navy, she was rechristened the Ysabel Segunda. Being rebuilt as an ironclad, she was the first steamship ever employed as a man-of-war, and the first in any service to be under fire. Her heavy timbers of oak and red pine, and strong construction in other respects, made her entirely worthy of her new vocation.

Goudie's peculiar hull has, however, a new interest at this time. For, without any reference to the means of propulsion to be employed, the cavities or depressions at the side are capable of adaptations for which the advancing demands of commerce may find great utility. Isthmian and other canals are requiring some new methods of obtaining steerage way, and he who can put sufficient propulsion at the bow of a steamer will do for navigation very much what Howe did for the sewing machine when he put an eye in the point of his needle. This has been attempted in combination with "the cavities or recesses on both sides of the vessel," which are shown in Goudie's model. Perhaps, with the improved means of propulsion now available, war vessels and merchant steamers of the largest class can be navigated through canals, or maneuvered in the presence of an enemy, far better than when the Ysabel Segunda entered the Spanish navy.

James Goudie, the naval architect who drew the plans, laid the keel, and superintended the construction of the Royal William, is an American citizen, and has been for many years a resident of Cook County, Illinois. His father, John Goudie, if not a Scotchman born, was of Scotch descent, and was a resident of Quebec on the 19th of December, 1809, when his son was born.

John Goudie and Henry Eckford (the famous naval architect of the war of 1812) were fellow apprentices in Quebec, in the ship yard of John Black, who was Eckford's maternal uncle. They were nearly of the same age, both having been born in the year 1775. During their apprenticeship a strong friendship grew up between them, which was ever afterward preserved. When they came to be of age, Eckford established himself in New York, but Goudie remained in Quebec, and was employed by the British government during the war of 1812–16 in constructing war vessels at Kingston, Isle aux Noix, and other places, while Eckford was similarly engaged by the United States government, at Sackett's Harbor and other points upon the lakes. They were professional rivals and well pitted against each other, but were always great personal friends.

Eckford had frequently written to his friend Goudie to send one of his boys to him and he would "make a Yankee of him." So finding himself an orphan at the age of fifteen, and hearing that Eckford was about to proceed to Turkey, to build a fleet of war vessels for that government, Goudie set out to join the expedition, but did not reach New York in time. Returning to Quebec, he was sent to Europe to complete his education, by the trustees of his father's estate; and proceeding from London to Yarmouth, and thence to Greenock, he apprenticed himself to an eminent shipwright, and after a brief term was made an assistant foreman to superintend the building of a steam yacht of four hundred tons, for Dom Pedro, on the same principle that he subsequently adopted for the Royal William. This resulted so much to the satisfaction of his employers that when, in the fall of 1830, they were solicited by the merchants of Quebec for some one to superintend the building of the proposed steamer, they unhesitatingly recommended young Goudie for the position. He accordingly returned to America, and made the plans; these being promptly approved, he was immediately engaged upon the work, with the result which we have already seen, although at the time scarcely twenty-one years of age.



THE SAVANNAH.

Fifty-seven years have elapsed since then, and in a letter he says: "I am getting pretty old now, but I try to keep active. I am just ten days older than Mr. Gladstone, 'the wood-chopper,' and I think his ideas are good, and I have followed them. When he dies, I shall look out."—*The Graphic, Chicago.*

The following from the SCIENTIFIC AMERICAN of

October 14, 1854, relating to the first voyage of the steamer Savannah, is of interest:

A REMINISCENCE OF THE FIRST OCEAN STEAMER.

In an out-of-the-way nook in the New York Crystal Palace, quietly reposing beneath the shelter of a glass case, the antique object which forms the subject of our engraving may be found.

It is the identical silver tea-kettle presented to Captain Moses Rodgers, of the American steamship Savannah, by one of his first passengers, Lord Lyndoch. In the same glass case may also be seen the original "log book" of the Savannah, which contains the usual nautical record of weather experienced, ports visited, and business on ship board, during the whole of her eventful career.

Few objects in the whole exhibition possess greater interest, to our minds, than the above named. They lay before us at a glance the particulars of the birth and paternity of that grand enterprise of modern times—Ocean Steam Navigation. They afford proofs direct and unmistakable that the progenitor of all those swift, iron-muscled leviathans which with foaming track and breathless speed now bid defiance to the billows of every ocean, here saw the light, and from these shores first sailed.

The Savannah was a vessel of 380 tons burden, ship rigged, and furnished with an inclined steam engine placed between decks, with boiler in the hold. Pine wood was the fuel. She was built in this city, by Messrs. Crocker & Fickitt. Her first voyage was from New York to Savannah, and thence direct to Liverpool, where she arrived after a passage of eighteen days, using steam only seven. She was provided with side paddle wheels, which were so arranged as to be easily taken off from their shafts and hoisted on deck. The following extract, which we have copied from the log-book, shows the facility with which the wheels were shipped and unshipped.

"REMARKS ON BOARD, JUNE 16, 1819.

Hour.	Knots.	
1.	3.	Course of wind S. E. by E.—W.N.W.
2.	3.	
3.	3.	These 24 hours begin with light
4.	3.	breezes and cloudy.
5.	2.	
6.	2.	
7.	2.	
8.	0.	At 8 P. M. calm and heavy sea. Got
9.	4.	steam up, and set the wheels to going,
10.	5.	took in all sail.
11.	5.	
12.	5.	
1.	5.	
2.	5.	
3.	5.	
4.	5.	
5.	5.	
6.	5.	
7.	5.	At 8 A. M. saw Mizen Head, on Ireland,
8.	5.	bearing east, 6 leagues distant.
9.	5.	At 9 took in the wheels and set sail.
10.	3.	At meridian, light breezes and pleasant.
11.	3.	Variation 2½ westerly.
12.	3.	Lat. by obs. 51° 22' N."

The above record, it will be observed, was made four days prior to the arrival of the steamer at Liverpool. It would appear that the vessel's average speed with fair wind, without steam, was three knots an hour, and that with steam alone, sails furled, five knots. Captain Rodgers seems to have been careful of his fuel, and to have used steam when the wind failed.

We make another extract from the log book, showing the record made on the day of her arrival at Liverpool, as follows:

"Remarks on board Sunday, 20th June, 1819—Wind N. W. These 24 hours begin clear; at 8 P. M. the Bardsey Islands, in Wales, bore east by compass, 5 leagues distant.

"At 4 A.M. see Holyhead Light, bearing N. E. by compass, 6 leagues distant.

"At 8 A. M. took pilot on board out of boat No. 10. At meridian pleasant.

"At 2 P. M. hove to off the bar for the tide to rise. At 5 P. M. shipped the wheels and furled the sails, and run into the river Mersey.

"At 6 P. M. came to anchor off Liverpool with the small bower anchor."

It appears rather questionable whether any of the newly invented propellers which have come into vogue since the days of Captain Rodgers have proved of greater convenience, or are more easily handled, so far as shipping and unshipping them is concerned, than the paddle wheels of the Savannah. We are inclined to think that an examination into their arrangement would be serviceable to those who are interested in steam as an auxiliary in navigation.

The arrival of the Savannah at Liverpool appears to have created considerable excitement. As she drew near the city with sails furled and American banners flying, the docks were lined by thousands of people, who greeted her with vociferous cheers. A Liverpool editor said, "Among the arrivals at this port on the 31st, we were peculiarly gratified and astonished by the novel sight of a fine steamship, which came around at half past seven, without the assistance of a single sheet, in a style which displayed the power and advantage of the application of steam to vessels of the largest size, being 350 tons burthen."

After remaining at Liverpool for about a month, the Savannah sailed to St. Petersburg, touching at Stockholm, where Lord Lyndoch took passage for the former place. This English nobleman was so much pleased with the trip that he presented Captain Rodgers with the silver tea-kettle represented herewith. The gift was accompanied with the following letter, which we copy from the original at the Crystal Palace:

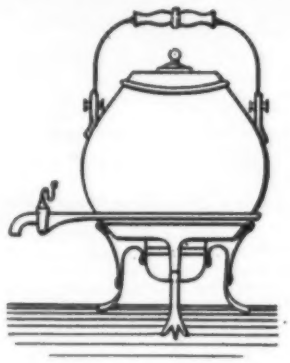
"St. Petersburg, 15th Sept., 1819.

Dear Sir: I trust you will do me the favor to receive the small tea kettle (or coffee pot) which I take the liberty of sending, as a slight token of my regard, and which may be useful at Mrs. Rodgers' tea table. I beg, too, that you will believe me most sincere in assuring you of the great satisfaction I had in making the passage from Stockholm on board the Savannah.

It gave me the opportunity of coming here in the most agreeable manner possible, and of admiring the successful efforts of your powerful mind.

With best wishes for your future welfare, in which Mr. Graham desires to join, I remain, dear sir, most truly and obediently yours, LYNDOCH.

Capt. Rodgers, of the Savannah."



The following is the inscription on the tea kettle:

"Presented to Captain Moses Rodgers,
of the Steamship Savannah.
Being the first steam vessel that had
crossed the Atlantic.
By Sir Thomas Graham—Lord Lyndoch,
a passenger from Stockholm to St. Petersburg.
September 15, 1819."

The testimonial may be described as having a beautiful false bottom, supported by three carved legs with ornamental claw feet, with a small vessel in the form of a lamp, on the top of which is a silver guard for the support of the kettle; the whole lined with gold and standing ten inches high.

The company owning the Savannah had dispatched her to St. Petersburg with the expectation of selling her to the Emperor, but in this they were disappointed and the ship returned to America. Owing to the great bulk of the wood fuel, it was found impossible to run her with profit, and her engine was removed. She ran as a sailing packet to the West Indies for a time, till at last, striking the Long Island shore, she became a wreck.

The engine was long used for manufacturing purposes, but has finally ceased its labors. The cylinder is still preserved, and the curious may look upon it in the machine room of the Crystal Palace, where it is exhibited by the proprietors of the Allaire Works of this city.

THE laughing plant is the name of a plant growing in Arabia. It has bright yellow flowers and soft velvety seed pods, each of which contains two or three seeds resembling small black beans. The natives of the district where the plant grows dry these seeds and reduce them to powder. A small dose of this powder has similar effects to those arising from the inhalation of laughing gas. It causes the most sober person to dance, shout, and laugh with the boisterous excitement of a madman, and to rush about cutting the most ridiculous capers for about an hour. At the expiration of this time exhaustion sets in, and the excited person falls asleep, to awake after several hours with no recollection of his antics.—*Medical Times.*

THE GIGANTIC LOCOMOTIVE ON THE ST. GOTHARD ROAD.

THE visitors at the last Paris exposition will remember the little narrow gauge railroad which ran from the Esplanade des Invalides to the machinery building, and which, in spite of its simple construction, carried over 6,000,000 passengers. This was made possible by the use of the so-called duplex locomotives, built according to the system of Anatole Mallet, a native of Switzerland, and resident of Paris. The first locomotive of this construction was used in 1887, during the exposition in Laon, on a grade of 7 to 100. This road, like that of the Paris exposition, was constructed by Decauville, at Petit-Bourg (Dept. Seine-et-Oise), on the same principle as the portable military roads with a gauge of only 24 inches. Since then the same system, with the little duplex locomotive, has been adopted by the French artillery, and locomotives of this class, of normal and narrow gauge, have been used to a certain extent, but recently a great many of these locomotives have been used, among which we may mention the powerful motors built at the Hirschau Iron Works of J. A. Maffei, in Munich, for the mountain service of the St. Gothard road and for the quarries of the Central Road of Switzerland. The locomotives for the latter have eight coupled wheels and weigh, when ready for service, 60 tons; while the Gothard engine has 12 coupled wheels, and, as it weighs 85 tons when fully equipped, it is the largest locomotive ever placed on a European railroad. The road from Vera Cruz to Mexico is the only one that has used heavier engines.

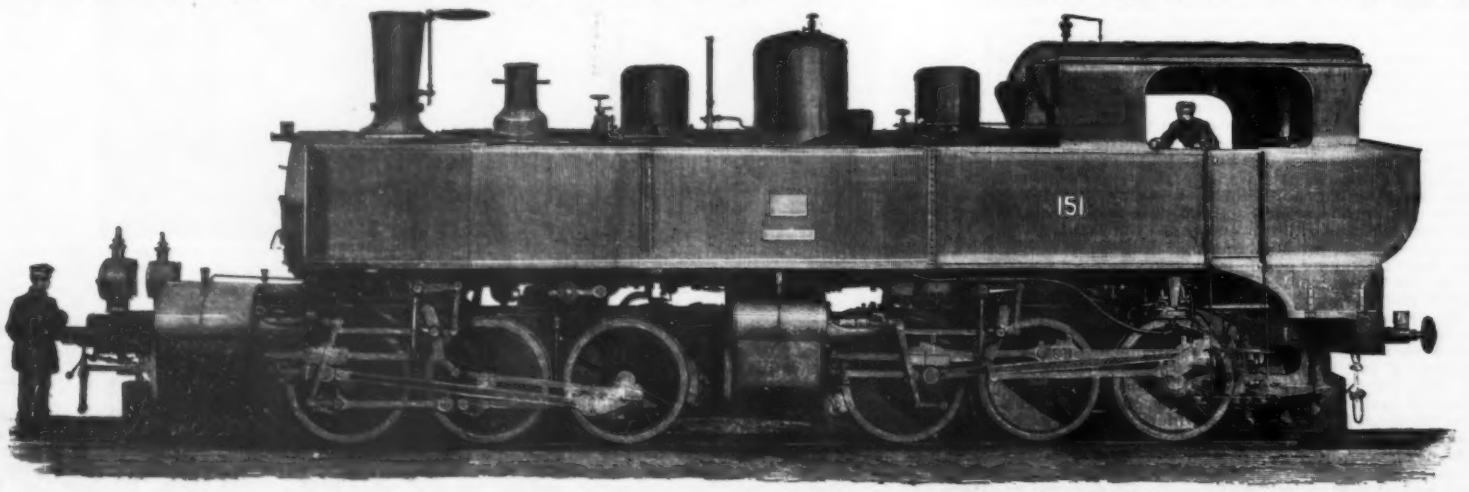
The gigantic locomotive of the Gothard road, which has run for some weeks past on the southern mountain stretch from Biasca to Airolo, is a combined tender and locomotive with four cylinders, the fuel and water carried by the locomotive serving to increase the friction on the rails and the tractive power. This arrangement is specially adapted for service on mountain roads in severe climates, particularly in winter, for, on the one hand, the weight is decreased, as there is no separate tender, and, on the other hand, the four connected cylinders permit a better utilization of the steam, and consequent saving of fuel and water. To allow the free movement of the locomotive on short curves, the running gear of the long engine is divided into two groups, the six wheels of each of which are connected with the mechanism belonging thereto. The two motor groups are connected by a joint and move toward each other horizontally. The duplex locomotive with six axles encounters no more resistance on curves than two ordinary three-axle engines, and the resistance is more easily overcome by the larger locomotive.—*Illustrirte Zeitung.*

THE YORKTOWN, CONCORD AND BENNINGTON, THREE NEW GUNBOATS.

THE official report of the forced draught trial trip of the gunboat Bennington, which has just been sent in, makes it possible to compare the three 1,703 ton gunboats which have been added to the new steel fleet. Such a comparison has a public interest, as illustrating the condition and progress of the art of naval construction in the United States in vessels of this class.

The Yorktown, Concord and Bennington are sister cruisers, the first named being built by the Cramps of Philadelphia, and the last two by the Quintard Iron Works of New York, using the yard at Chester. They are practically identical in dimensions, being 228 feet long by 36 beam, 18¾ in depth of hold from top of main deck beams to top of floors, and 14 in mean draught, except that the Concord is put at 14 feet 4½ inches. Each has a maximum coal capacity of 400 tons in the bunkers.

The machinery also is of the same type, each vessel having a single triple expansion engine, the diameters of the three cylinders being respectively 22, 31 and 50 inches, with a common stroke of 30 inches. Each has four steel boilers, 17¾ feet long by 9¾ feet diameter, and in each there are three corrugated furnaces, having a maximum diameter of 41 inches and a minimum of 37. Keeping in mind these common points of the machinery in the three vessels, it is next to be noted that the Yorktown's contract called for the development of 3,000 horse power, but in her actual trial she reached over 3,392. Accordingly, in the contract for the Concord and Bennington, a minimum of 3,400 horse power was exacted. The contract price for the Yorktown had been $455,000, and she had earned in premium, at the stipulated rate of $100 for each unit of surplus in horse power, close upon $40,000. Accordingly, the new contract, in calling for 400 more horse power, could afford at the same rate to pay $40,000 more for each vessel, or $495,000. The Quintard Iron Works stipulated to build the Concord and Bennington at $490,000 each. The following tabulated



THE NEW GIANT LOCOMOTIVE OF THE ST. GOTHARD ROAD.

statement will tell the remainder of the facts developed on the trial of the three sister ships and the results accomplished:

DATA OF MACHINERY AND RESULTS.

Data of trial.	Yorktown, Feb. 13, 1889.	Concord, Jan. 13, 1891.	Bennington, April 2, 1891.
Total heating surface, for one boiler, sq. ft.	2,022·97	2,052·42	2,052·42
Grate surface (one boiler)	55	55	55
	feet. in.	feet. in.	feet. in.
Pitch of screw	12 6	13 2·45	13 8⅝
Steam at boilers, pounds	150·5	164·3	166·06
Steam at engines, pounds	143·55	159·75	161·05
Steam at first receiver, absolute	70·7	78·275	76·65
Steam at second receiver, absolute	20·15	28·77	33·17
Vacuum in condenser, in inches	24·93	24·05	23·81
Revolutions of main engines	156·06	132·41	150·973
Temperature of injection, Fahrenheit	40·4	36	38·2
Temperature of discharge	92·6	105·5	92·8
Temperature of feed	90·8	130·9	125·8
Air pressure in inches of water	1·25	2·292	2·45
Revolutions of blowers	7·37	497·5	514·82
Revolutions of air and circulating pumps	121·75	51·15	57·3
Mean effective pressure H. P. cylinders, pounds	56·66	53·493	56·57
I. P. cylinders	34·19	29·598	27·50
L. P. cylinders	10·57	15·187	15·63
Indicated horse power, H. P. cylinders	1,015·17	928·742	973·80
I. P. cylinders	1,220·67	1,038·750	945·61
L. P. cylinders	909·44	1,358·802	1,403·39
Collective horse power of main engines	3,206·28	3,314·303	3,322·80
Indicated horse power air and circulating pumps	118·79	27·388	36·62
Blower engines	52·03	34·774	45·92
Feed pumps	16·15	17·624	20·49
Dynamo engine	....	8·00	7·76
Steering engine	....	2·50	2·50
Aggregate horse power main engines and auxiliaries	3,302·25	3,404·589	3,436·09
Per cent. of horse power of auxiliaries to main horse power of main engine	5·8*	2·7	3·4
Speed in knots, average four hours	16·14	16·8	17·5
Speed in knots, maximum	17·2	17·4	17·8
Contract price, dollars	$455,000	$490,000	$490,000
Premium, dollars	39,225	452.90	3,609
Total cost to U. S.	494,225	490,452.90	493,609

*Omitting horse power of dynamo and steering engines. It may be noted here that the air pressure in the Yorktown is in the fire room; in the Concord and Bennington, in the ash pans.

It is a subject of congratulation for the navy, and for the builders of these handy, useful and economical vessels, that the pioneer of her class, the Yorktown, exceeded by 392¼ horse power the requirements of her contract, and that the Concord and Bennington have now each slightly surpassed even the Yorktown in horse power, with machinery built later on the same plans. But still more remarkable is the gain in speed effected by the two later vessels of this class. The Concord gains, it would appear, one-fifth of a knot over the Yorktown's maximum, and makes the still more important gain of two-thirds of a knot over the Yorktown's average for the four hours together. But the Bennington now makes as great an advance above the Concord as the Concord had made above the Yorktown. She surpasses the Yorktown by three-fifths of a knot at her maximum, and, what is much more worthy of note, she shows herself to be upward of a knot and one-third faster than the Yorktown in the average of a sustained forced draught trial during four consecutive hours.

Had the contract for the Concord and Bennington been based in its provisions for premium on achieving a greater speed than the Yorktown, instead of on reaching greater horse power, the contractors, instead of the $4,062 extra they have earned, would at the usual rates reap a very large reward.

The Bennington is now to be submitted to some alterations, which have been suggested both by the experience of the Yorktown and by that of the Archer class in the British navy, and these, it is believed, will make her still more serviceable.

COAL TAR OR ANILINE DYES.

THESE are characterized for the most part by their easy solubility in water, the brilliancy of the colors they produce, and by their great dyeing or tinctorial power. Their disadvantage, compared with the mineral and other organic colors above given, lies in the fact that they are unstable or are liable to change when exposed to the atmosphere. Their examination is, therefore, often very difficult. Competing color makers and color dealers frequently introduce the same dye into the market under different names. It is important for the consumer to know whether any dyes offered to him as novelties are really new bodies or are only well-known colors sold under a different name.

It is difficult to ascertain with certainty, by chemical test, the true nature of many classes of dyes, as many of these are compound colors. They are frequently mixed with other bodies to reduce their relative tinctorial power. These bodies are sugar, dextrin, common salt, Glauber salts, sulphate of magnesia, etc. The presence of metallic salts may easily be ascertained by burning a quantity of the dye in a platinum capsule and examining the residue.

The following list of reactions of the principal dyes occurring in commerce is compiled by Dr. Otto Witt:

RED DYES.

A. *Insoluble or very difficultly soluble in cold and hot water.*

1. *Magdala-red.*—The alcoholic solution is blue-red, with strong cinnabar-red fluorescence; solution in concentrated sulphuric acid is greenish gray, and, when diluted with water, first turns red and finally reddish-violet.

2. *Chinolin-red.*—Insoluble in cold water, and slightly soluble in hot water. The alcoholic solution behaves as the above. The sulphuric acid solution is, however, colorless, and on dilution with a known quantity of water is changed to a deep magenta-red.

3. *Eosin (soluble in alcohol).*—The alcoholic solution shows a greenish fluorescence. Solution in concentrated sulphuric acid is citron-yellow or orange, no essential change taking place on dilution with water.

4. *Rhodindine.*—The alcoholic solution is dirty-bluish red. Solution in concentrated sulphuric acid is green, which, on dilution with water, changes to blue-red.

B. *Soluble in cold water and easily so on heating.*

A. *The addition of caustic soda to the solution causes a precipitate.*

BASIC COLORS.

Fuchsine — Aniline-red, Magenta. — The aqueous solution is blue-red, and changed to yellow-brown by hydrochloric or sulphuric acid, the original red being restored on addition of acetate of soda. Sticks of zinc immersed in the solution completely and permanently decolorizes it. A dilute ammoniacal solution dyes wool an intense red, especially on boiling. The solid dye consists of green crystals, or is a green powder with metallic luster, and dissolves in sulphuric acid, yielding a yellow-brown solution.

2. *Toluylen-red (neutralized).*—The aqueous solution is blue-red; the addition of ammonia produces orange colored flakes, which are dissolved by ether, forming a red-colored solution with yellow fluorescence. Solution in concentrated sulphuric acid is green, and on dilution with water is changed first to blue, then violet, and finally red.

B. *No precipitate is produced when caustic soda is added to the aqueous solution of the dye.*

ACID OR BASIC DYES OF THE SAFRANIN CLASS.

1. *Gallein.*—Caustic soda added to the aqueous solution produces an intense blue. The solution in concentrated sulphuric acid is brown-yellow, and changed to a reddish shade on dilution with water.

2. *Safranin.*—On adding alcohol to the aqueous solution, a decided grayish yellow fluorescence is produced. Acids give no precipitate. Zinc powder decolorizes the solution, but on exposure to the air the red color is restored. Solution in concentrated sulphuric acid is green, but on dilution changes first into ink blue, and then into red.

3. *Eosin.*—The aqueous solution is pure red, with greenish yellow fluorescence, which increases in intensity as the solution is diluted. By transmitted light the solution appears red. Acids produce orange-yellow flakes, which are soluble in ether. This ether solution is not fluorescent, but is pure yellow. Solution in concentrated sulphuric acid is yellow.

4. *Eosin-scarlet.*—The aqueous solution is bluish red without fluorescence. Acids produce a straw-yellow precipitate, soluble in ether. Solution in concentrated sulphuric acid is golden yellow. Zinc powder in presence of ammonia decolorizes the solution. This discolorized solution, when dropped into filter paper and exposed to the atmosphere, changes to blue-red.

5. *Phloxin—Rose Bengal.*—Aqueous solution, blue-red, without fluorescence. Acids produce an orange-yellow precipitate, soluble in ether. Concentrated sulphuric acid dissolves the dye with orange-yellow color. Metallic zinc in presence of ammonia decolorizes the aqueous solution, but the color is not restored, or is very feebly so, on exposing the solution to the air.

6. *Biebricher—Scarlet.*—The hot, concentrated solution of the dye solidifies on cooling to a jelly-like mass. Acids produce a brown flocculent precipitate. On heating with zinc in presence of ammonia the solution is first pure yellow, and finally is decolorized. Concentrated sulphuric acid dissolves the dye, forming a grass-green fluid, which on dilution with water first becomes blue, and then a dirty brown precipitate separates out.

7. *Crocein-scarlet.* 3 *B.* — The aqueous solution yields on the addition of chloride of barium a flocculent red precipitate, which suddenly crystallizes to a violet black powder on boiling, otherwise the solution is indigo blue, and passes from violet into red on dilution.

8. *Congo red.*—The aqueous solution is colored blue by the addition of a trace (one drop) of acid. Cotton is dyed fast on boiling in the aqueous solution. Concentrated sulphuric acid yields a slate blue fluid, which does not alter in color on dilution with water.

9. *Xylidin-ponceau.*—Bronze glistening crystals separate on cooling a hot concentrated solution. Concentrated sulphuric acid yields a violet fluid, from which a brown precipitate is obtained on adding water.

10. *Crocein-scarlet, 7 B extra.*—On cooling a hot concentrated solution solution containing sulphate of magnesia, long-glistening needle-shaped crystals are obtained. Sulphuric acid dissolves the dye, yielding a violet solution. Wool is dyed a beautiful scarlet red.

11. *Acid Azo-rubin.*—Chlorides of calcium or barium, when added to the aqueous solution, yield an amorphous flocculent precipitate. Concentrated sulphuric acid dissolves it, yielding a pure rose-red or carmine-red fluid. On dilution with water brown-red precipitates are obtained for ponceau R, 2 R, 3 R, anisol-red and coccin. These colors are distinguished by their individual shades or tones.

12. Dyes wool magenta-red. Chloride of calcium produces a red flocculent precipitate in the aqueous solution. Solution in concentrated sulphuric acid is bluish-violet, changing to red on dilution.

13. *Echt-red or Rocelline.*—The aqueous solution is deep brownish red; dyes wool the same color. Solution in concentrated sulphuric acid is blue, and when water is added to this blue solution, a yellowish-brown precipitate separates. When a few drops of saturated soda solution are added to a boiling concentrated solution of the dye, brown shining scales separate out.

14. *Bordeau B.*—The aqueous solution is Bordeau-red. The addition of chlorides of calcium or barium produce a flocculent amorphous precipitate. Concentrated sulphuric acid dissolves it with indigo blue color.

15. *Acid-fuchsine.*—Aqueous solution beautiful bluish-red color, which is completely decolorized by caustic soda. Acetic acid restores the original color.

YELLOW AND ORANGE DYES.

A. The dye is insoluble in cold water, or very difficultly soluble in hot water, but easily soluble in alcohol.

1. *Chinophtalon.*—The alcoholic solution is citron-yellow, which undergoes no change on the addition of alkalies or acids, or, at most, the tone of the color is only deepened.

2. *Curcuma.*—The solution is golden yellow, and undergoes no changes on the addition of acids. Alkalies and boracic acid change it to a brown red.

3. *Dimethylamidoazobenzol.*—The solution is golden yellow, which is changed to red by hydrochloric acid. The hydrochloric acid solution, with amyl nitrite, changes the color, and when boiled nitrogen is evolved.

4. *Amidoazobenzol.*—Behaves as No. 3. Amyl nitrite changes its color with only a slight evolution of nitrogen.

B. The dye is freely soluble in water, and concentrated sulphuric acid dissolves it without strong coloration.

ACID DYES.

(a) Caustic soda produces no precipitate.

(b) If caustic soda produces a precipitate in the aqueous solution.

1. *Picric acid.*—Greenish yellow solution possessing a very bitter taste. Alkalies change it to a dark yellow, while acids produce no change.

2. *Martins yellow.*—Solution, golden yellow. Acids produce a whitish precipitate.

3. *Acid naphthol yellow.*—Solution, golden yellow. Not precipitated by acids. The addition of chloride of potassium yields fine needles.

4. *Fluorescene and benzyl fluorescene.*—Solution, brown yellow with beautiful green fluorescence, which diminishes with the formation of a precipitate on the addition of acid.

5. *Chinoline yellow.*—Solution, golden yellow, in which acids produce no precipitate. Decolorized by metallic zinc in presence of ammonia, and also by stannous chloride in presence of hydrochloric acid.

BASIC DYES.

1. *Phosphine.*—The addition of alkalies produces a yellow flocculent precipitate solution in ether, yielding a pure yellow solution possessing a powerful green fluorescence.

2. *Flavaniline.*—Alkalies yield a milk-white precipitate, which is dissolved by ether, forming a colorless solution with greenish blue fluorescence.

3. *Auramin.*—Alkalies produce a milk-white precipitate, which is dissolved by ether without fluorescence. The yellow solution, when boiled with hydrochloric acid, appears at first brighter, but finally fades.

C. The dye is soluble in water. Solution in sulphuric acid is very stongly colored.

AZO DYES.

(a) Caustic soda produces a precipitate in the aqueous solution.

1 *Chrysoidine.*—Wool is dyed yellow. The aqueous solution coagulates to a blood red colored mass, soluble in sulphuric acid, forming a brownish yellow solution.

2. *Vesuvin (Bismarck brown) phenylene brown.*—Wool is dyed orange brown. The aqueous solution does not solidify on cooling. Solution in sulphuric acid brown.

(b) Caustic soda produces no precipitate.

1. *Echt yellow.*—Solution in sulphuric acid is yellow. After dilution with water, salmon red. Aqueous solution, yellow.

2. *Methyl orange and ethyl orange.*—Solution in sulphuric acid yellow, when diluted carmine red. Aqueous solution yellow, which, in cooling, yields gold glistening plates. Dilute acids give a shining red violet precipitate.

3. *Tropaeolin O O.*—Solution in sulphuric acid violet, on diluting red violet, and giving steel gray precipitate. Solution in water yellow, crystallizing on cooling. Chlorides of calcium and barium give insoluble precipitates.

4. *Jaune N.*—The sulphuric acid solution is blue green, changing to violet on diluting with steel gray precipitate. Aqueous solution yellow, which crystallizes on cooling. Chloride of barium gives a yellow precipitate, soluble in a large volume of water, and from which the precipitate crystallizes out again in the form of plates.

5. *Luteoline.*—Solution in sulphuric acid is yellow green, after dilution it changes to violet, with formation of a gray precipitate. Aqueous solution is yellow, which crystallizes in cooling. Chloride of calcium gives an orange red precipitate, which changes to red on boiling, and crystallizes.

6. *Citronin (Jaune indien).*—The sulphuric acid solution is carmine red, changing to yellow on dilution. The aqueous solution is yellow and often turbid. Alcoholic caustic soda lye changes the color from deep red to violet.

7. *Orange G.*—Solution in sulphuric acid, deep orange, which does not essentially change on dilution. The aqueous solution is orange, and by the addition of chloride of calcium, very beautiful plate-like crystals of the calcium salt separate out.

8. *Tropaeolin O.*—The sulphuric acid solution is brown orange—not changing essentially in color when diluted. Aqueous solution yellow, from which beautiful yellow crystalline plates may be obtained on the addition of a little hydrochloric acid. A large excess of acid separates the free dye in gray needles.

9. *Orange II.*—Solution in sulphuric acid, carmine red, turning to orange on dilution. The aqueous solution is reddish orange. Chloride of calcium gives a beautiful red precipitate, which is soluble in a large volume of water, and crystallizes from it in needles.

10. *Tropaeolin O O O.*—Solution in sulphuric acid, violet, changing to orange on dilution. The aqueous solution is reddish orange; caustic soda changes it to carmine red.

GREEN DYES.

1. *Cærulein.*—Sparingly soluble in water with olive brown color. The addition of alkalies renders the dye more soluble, producing a grass green solution. Concentrated sulphuric acid dissolves it, yielding a dirty brown solution.

2. *Victoria green and brilliant green.*—Easily soluble in water, yields a beautiful green solution. Alkalies throw down rose or gray precipitates, strong acids color it yellow.

In order to distinguish both of these colors from one another, a small piece of wool is dyed in a bath and the shades compared.

3. *Iodine and methyl green.*—Easily soluble in water—blue green solution. Acids change it to yellow, while alkalies decolorize it without precipitation. When the solid dye is heated above 100° C., it appears violet.

4. *Blue dyes.*—Easily soluble in water, forming a slightly greenish solution. Acids intensify this color,

and when added in larger quantity, change it to yellow. Alkalies decolorize it completely. Silk and sulphurized wool are dyed in the acid bath (methyl green in a neutral bath), and dyed samples may be heated to 130° C. for a short time, without altering their shade. Sulphoacids of benzaldehyde greens, especially *light green S, emerald green, Helvetia green.*

1. *Rosaniline and diphenylamine blue.*—Soluble in alcohol, but quite insoluble in water. Hydrochloric acid does not essentially change the color, frequently small green crystals separate. Caustic soda solution changes it to a brown red color. Concentrated sulphuric acid dissolves it, forming a bright reddish brown solution.

2. *Indophenol.*—Insoluble in water, but soluble in alcohol. The alcoholic solutions are colored red on the addition of hydrochloric acid, while alkalies produce no change.

3. *Methylene blue.*—Easily soluble in water. The blue solution is rendered greenish by hydrochloric acid and violet red by soda. Zinc powder reduces and decolorizes the solution, but the color returns again on exposing the solution to the atmosphere. Zinc may be detected in the ash (obtained by incinerating some of the original dye) in the following way. The zinc exists as chloride. The ash is dissolved in water, filtered if necessary, and ammonia added to precipitate the zinc as hydrate, ZnH_2O_2; a white precipitate, soluble in excess of ammonia. The clear solution thus obtained yields with sulphureted hydrogen or sulphide of ammonium, a white precipitate of sulphide of zinc (ZnS) which is insoluble in acids.

4. *Victoria blue.*—Easily soluble in water. The blue color is changed to yellow brown by acids, while alkalies, yield a reddish brown precipitate.

5. *Alkali blue R, 6 B.*—Easily soluble in water, the solution being nearly decolorized by alkalies. Wool absorbs the color from the alkaline solution, and after washing with water and dipping in a weak acid bath, is changed to deep blue.

6. *Water blue R, 6 B.*—Easily soluble in water. Wool is dyed in the acid solution. Alkalies do not change the color of the aqueous solutions. Sticks of zinc decolorize the solution.

7. *Indigo carmin.*—Easily soluble in water, but the color is developed only after the addition of acid. Zinc, in presence of ammonia, decolorizes the aqueous solution, but the color is reproduced on exposure to the air. Dilute nitric acid oxidizes and permanently decolorizes the coloring matter, especially on boiling.

8. *Induline R, 6 B.*—Insoluble in water, but soluble in alcohol. Alkalies change the alcoholic solution brownish red to violet. Solution in concentrated sulphuric acid is blue.

9. *Induline soluble in water.*—Soluble in water. Acids throw down the blue, alkalies color it red or violet. Zinc in presence of ammonia decolorizes the aqueous solution, the color reappearing on exposing the solution to the atmosphere. Dilute nitric acid does not decolorize the aqueous solution, even on heating.

10. *Lenk indophenol.*—Gray paste, which produces immediately a blue coloration when mixed with soda lye and exposed to the air.

11. *Orthonitrophenylpropiolic acid.*—Gray paste, soluble in soda lye without the formation of a blue color. When boiled with grape sugar, indigo blue crystals separate out.

VIOLET DYES.

1. *Regina purple.*—Soluble with difficulty in water; easily soluble in alcohol. Solution in sulphuric acid cinnamon brown.

2. *Methyl violet R, 6 B. Hoffmann's violet.*—Easily soluble in water, alkalies alter the color. Hydrochloric acid first colors it green, then yellow.

3. *Mauvein.*—Not very easily soluble in water. Alkalies produce a violet separation. Solution in concentrated sulphuric acid is gray, and when this solution is gradually diluted, it undergoes the following changes: gray green, sky blue, blue violet, and red violet.

4. *Lauth's violet.*—Soluble in water, acids change the color to pure blue, alkalies to red violet. Metallic zinc, in presence of acids or ammonia, completely decolorizes the solution, the original color of which reappears on exposing to the air. Concentrated sulphuric acid dissolves the dye, yielding an emerald green solution, which changes to sky blue on diluting it with water.

5. *Gallo cyanin.*—Only soluble in boiling water. Hydrochloric acid colors the solution a pure carmine red. Solution in concentrated sulphuric acid, blue; on diluting with water changed to red.

6. *Amethyst, fuchsia, giroflé.*—Solution in water with red violet solution; the addition of alcohol produces a carmine red fluorescence. Concentrated sulphuric acid dissolves it, yielding an emerald green solution, which, on dilution, changes to blue or violet.—*Chem. Tr. Jour.*

ELLIPSES AND EQUIVALENT OVALS OF EQUAL AREAS.

By FREDERIC R. HONEY, Ph.B., Instructor in Descriptive Geometry, etc., Trinity College.

WITHIN certain limits a fair approximation to an ellipse may be made by drawing a four-centered oval; and it is desirable to ascertain on some definite principle the lengths of the radii with which the arcs should be described.

Fig. 1 illustrates the well known construction. This figure, which has already been explained in the SCIENTIFIC AMERICAN,* must be repeated here as preliminary to the subject under consideration. In the article referred to, approximations to the curve were made by drawing arcs of circles through points which conformed to the equation of the ellipse. In the present article a method by *equivalent areas* will be demonstrated.

Let $a\,b$ and $c\,d$ (Fig. 1) be the major and minor axes intersecting at the center, o. Assume a point, e, between c and o, and lay off from the extremity of the major axis a distance, $b\,f$, equal to $c\,e$. Draw the line, $e\,f$, and bisect it at g. Draw $g\,h$ perpendicular to $e\,f$, intersecting the minor axis, or the minor axis produced, at h. Lay off $o\,j$ equal to $o\,f$, and $o\,i$ equal to $o\,h$; $f\,j\,h$ and i are the required centers. Draw the lines, $h\,f$, $h\,j$, $i\,f$ and $i\,j$, and produce them. With f and j as centers, and with a radius, $f\,b\,(=j\,a)$, draw the arcs, $l\,b\,m$ and $k\,a\,n$. With h and i as centers, and with a radius, $h\,c\,(=i\,d)$, draw the arcs, $k\,c\,l$ and $m\,d\,n$.

From the construction it will be seen that these arcs have common tangents at the points, k l m and n.

Let $f\,b\,(=j\,a) = r$, the radius with which the arcs, $l\,b\,m$ and $k\,a\,n$, are described.

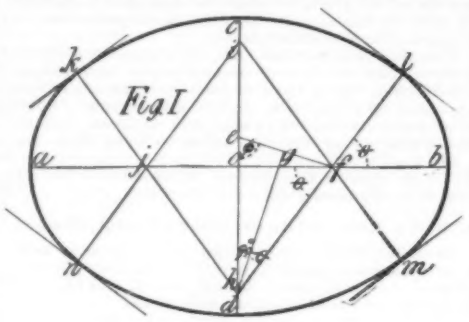
Let $h\,c\,(=i\,d) = \mathrm{R}$, the radius with which the arcs, $k\,c\,l$ and $m\,d\,n$, are described.

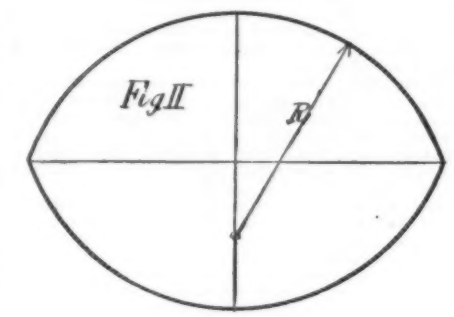
Let $o\,b = \mathrm{A}$.

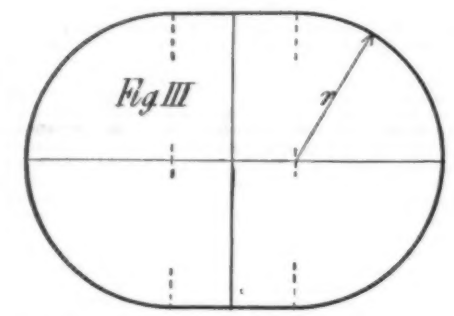
Let $o\,c = \mathrm{B}$.

Let the angle $l\,f\,b\,(=o\,f\,h) = \theta$.

The length of R in terms of r is determined by the







similar right-angled triangles, $f\,o\,e$ and $h\,g\,e$, which have a common angle, θ.

Thus $f\,e : e\,o \;.:\; h\,e : e\,g$

$$\therefore h\,e = \frac{f\,e \times e\,g}{e\,o}$$

And since $h\,e = h\,c - e\,c = \mathrm{R} - r$

$$\text{“} \quad f\,e = \sqrt{\overline{e\,o}^2 + \overline{o\,f}^2} = \sqrt{(\mathrm{B}-r)^2 + (\mathrm{A}-r)^2}$$

$$\text{“} \quad e\,g = \frac{f\,e}{2} = \frac{\sqrt{(\mathrm{B}-r)^2 + (\mathrm{A}-r)^2}}{2}$$

$$\text{“} \quad e\,o = o\,c - e\,c = \mathrm{B} - r$$

$$\therefore \mathrm{R}-r = \frac{\sqrt{(\mathrm{B}-r)^2 + (\mathrm{A}-r)^2}}{\mathrm{B}-r} \times \frac{\sqrt{(\mathrm{B}-r)^2 + (\mathrm{A}-r)^2}}{2} = \frac{(\mathrm{B}-r)^2 + (\mathrm{A}-r)^2}{2\,(\mathrm{B}-r)}$$

$$\therefore \mathrm{R} = \frac{(\mathrm{B}-r)^2 + (\mathrm{A}-r)^2 + 2\,r\,(\mathrm{B}-r)}{2\,(\mathrm{B}-r)} = \frac{\mathrm{A}^2 + \mathrm{B}^2 - 2\,\mathrm{A}\,r}{2\,(\mathrm{B}-r)}$$

Now since r may be any length between zero and B, the limiting figures constructed as above will be determined by putting r equal to zero, in which case $\mathrm{R} = \frac{\mathrm{A}^2 + \mathrm{B}^2}{2\,\mathrm{B}}$, and we have two arcs of circles (Fig. 2.)

Putting r equal to B, the denominator of the fraction reduces to zero, and $\mathrm{R} = \infty$, and Fig. 3 becomes two semicircles described with a radius equal to B connected by two parallel lines. Since the length of r is arbitrary, the figure may be anything between these two limiting cases.

In order to make r and R definite, it is proposed to calculate the lengths of these radii when the area of the oval is equal to that of the ellipse constructed on the same axes.

It will be sufficient to consider the quadrant $o\,b\,l\,c$, whose area is equal to the sum of the areas of the sector

$$h\,c\,l \left(= \pi\,\mathrm{R}^2\,\frac{90°-\theta}{360°}\right)$$

and the sector

$$f\,l\,b \left(= \pi\,r^2\,\frac{\theta}{360°}\right)$$

diminished by the area of the triangle

$$f\,o\,h \left(= \frac{\overline{\mathrm{R}-\mathrm{B}} \times \overline{\mathrm{A}-r}}{2}\right)$$

Equating this area to that of the quadrant of the ellipse

$$\left(= \frac{\pi\,\mathrm{A}\,\mathrm{B}}{4}\right)$$

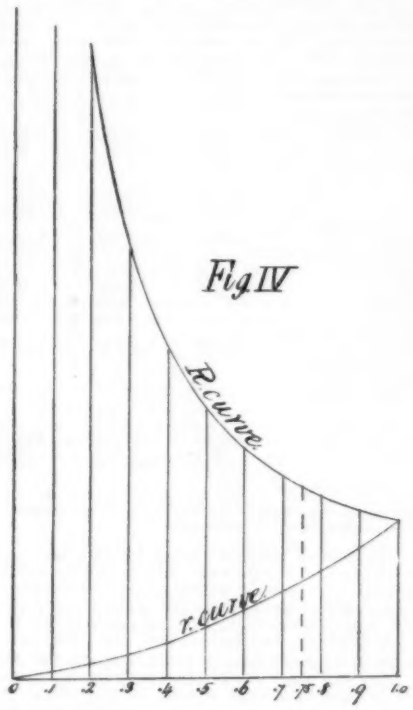
we have

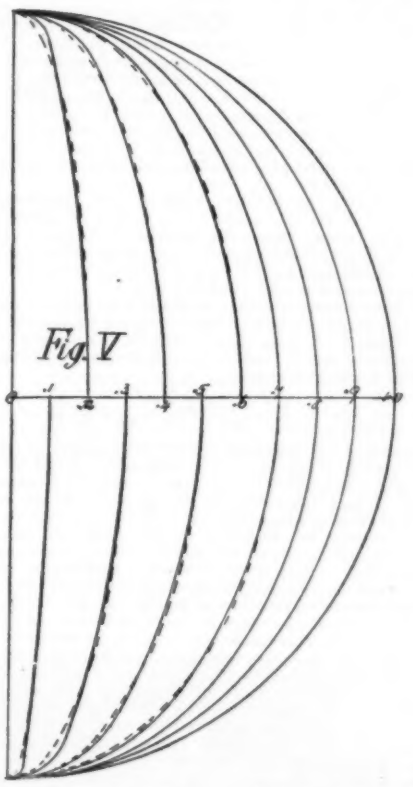
$$\pi\,\mathrm{R}^2\,\frac{90-\theta}{360} + \pi\,r^2\,\frac{\theta}{360} - \frac{(\mathrm{R}-\mathrm{B})\,(\mathrm{A}-r)}{2} = \frac{\pi\,\mathrm{A}\,\mathrm{B}}{4}$$

or, dividing it by π

$$\mathrm{R}^2\,\frac{90-\theta}{360} + r^2\,\frac{\theta}{360} - \frac{(\mathrm{R}-\mathrm{B})\,(\mathrm{A}-r)}{2\,\pi} = \frac{\mathrm{A}\,\mathrm{B}}{4} \qquad [\mathrm{I}]$$

In this equation there are four variables, viz., r, R, θ and $90°-\theta$. The last three are dependent upon r, A and B.





$$\mathrm{R} = \frac{\mathrm{A}^2 + \mathrm{B}^2 - 2\,\mathrm{A}\,r}{2\,(\mathrm{B}-r)}$$

$$\tan\theta = \frac{h\,o}{o\,f} = \frac{\mathrm{R}-\mathrm{B}}{\mathrm{A}-r}$$

Equation I. is solved for r, R and θ approximately.

The proportion between the minor and major axes of the oval is indicated by the fraction in the left hand vertical column of the table, *i. e.*, the numerator bears to the denominator the proportion of the minor axis to the major axis. The values of r and R are found in the horizontal column following the fraction which represents this ratio; and in using them it should be understood that the measurements are given in terms of the semi-major axis—that is, in any given case the semi-major axis should be multi-

* See SUPPLEMENT, July 5, 1890.

plied by r and R in order to ascertain the true lengths of the radii which are to be employed in drawing the arcs.

θ	$\frac{r}{\theta}$	$\frac{R}{\infty}$
0·1	0·041	7·888
0·2	0·094	4·019
0·3	0·159	2·740
0·4	0·237	2·107
0·5	0·329	1·731
0·6	0·434	1·483
0·7	0·554	1·308
0·8	0·688	1·179
0·9	0·837	1·079
1·0	1·000	1·000

In order that the draughtsman may be provided with the measurements for r and R when the proportion between the minor and major axes lies *between* the ratios exhibited in the table, it is desirable to construct curves (Fig. 4) whose ordinates may be any convenient distance apart, and which should be equal to the measurements given in the table. The ordinates for r increase from zero to unity; those for R from unity to infinity. In constructing these curves, in order to secure accurate work, it is desirable to employ a large unit. One example will suffice to explain the method of using Fig. 4. Let the ratio of the minor to the major axis be in the proportion of three to four (= 0·75); 0·75 lies between 0·7 and 0·8. Produce the ordinate—represented by a broken line in the figure—until it meets the r and R curves. The lengths of these ordinates will give the required dimensions.

Fig. 5 illustrates parts of four-centered ovals constructed on the same axes as the corresponding ellipses, the radii being computed from the table. The ovals are drawn in full lines; the ellipses in broken lines.

It will be seen that by determining r and R from the table, the construction of Fig. 1 is avoided.

THE USE OF CLOISONNE FOR DECORATION IN ANCIENT AND MODERN TIMES.*

By CLEMENT HEATON.

THE decorative art described as *cloisonne* has been so lost sight of in modern times that, except for the works of art brought from the East, it might be considered as practically non-existent. Even at the present day the word *cloisonne* gives no idea at all to the majority, and to the greater part of those who have some idea of what it is, it recalls to mind only the vases of China and Japan. It is, therefore, somewhat surprising to find that it is one of the very oldest forms of art, and that it has no unimportant and local history, but has been widely spread, and has, moreover, given rise to or greatly influenced other arts more important than itself.

To trace its history I shall have to make a wide though necessarily brief review, but I shall do so from the standpoint of an artist and craftsman, and not as an archæologist, and with the view of showing what place *cloisonne* has held as an art in bygone days, and how it can be used now.

But before tracing its history it may be well to make clear the exact nature of the work. The French name "*cloisonne*," meaning "inclosed work," gives at once the idea of its leading characteristic, which is the use of a dividing line, edge, or *cloison*. This *cloison* forms a cell in which colored material is held, and its surface forms a neutral line between the various colors. This edge may evidently be produced in several ways. Thus a ribbon of metal may be bent and soldered down to a ground, which gives a *cloisonne* proper; if, instead of a ribbon, an ordinary round wire be used, we get a filigree, or enameled filigree if enamel is introduced. Again, a surface of material such as metal, stone, wood, etc., may be dug into, and the ground cut away, leaving the edges standing. This gives a *champleve*. The *cloisonne* gives as result fine even lines, and a delicate effect; the *champleve*, strong variable lines, and a rich effect. In thin, ductile, or plastic material, hollows and edges may be formed by depressing and elevating the surface, the hollows being afterward enameled; or moulds may be made with cells prepared to receive color filling. In the case of earthenware, fillets of clay can be attached to the ground, and enamel floated between the lines.

These various ways of forming an inlay with dividing lines to fields of color may be all classed under the system of *cloisonnage*. Other forms of inlay approach very closely to this work, as *intagliatura*, *niello*, *intarsia*, damascening, and *boule* work. And the decorative effect of the *cloison* has often been copied in enameled earthenware and painting.

Into the spaces so formed color is introduced, and this in a variety of ways. The oldest form is the insertion of pieces of fine stone, etc., cut to shape, and inlaid or *enchasse;* colored cements and encaustics were also used at an early date; and lastly, long after the system of *cloisonnage* had been established—probably over a thousand years after—vitreous enamel was used as a filling. The use of enamel, then, is far from being indispensable to produce a *cloisonne*, and *cloisonne enamel* is only one section of the art, as vitreous mosaic is of mosaic.

The artistic effect produced by any of these methods is essentially decorative. It yields a flat and colored surface, with the colors divided by lines of some metallic or neutral material; and this division and blending of the colors is so eminently beautiful that it has influenced design in other arts to a remarkable extent.

It is natural that personal adornments, and the embellishments of arms and implements, should have been the first things to which civilized people have turned their attention; and it seems that the blending of precious metals with color, in the form of *champleve* or *cloisonne*, has been one of the earliest products in art; and this, as the most precious work known to the possessors, has afterward been copied in other materials, and has influenced early forms of both painting and architectural ornament.

We must therefore clearly distinguish between *cloisonne*, as limited to jewelry, and as applied to decoration, either in the form of inlay or the system of design based upon it.

Some few years ago a piece of Damascus enameled work suggested to me that *cloisonne* would form a beautiful medium for the decoration of walls, and since that time I have worked out a system of *cloisonnage* for this purpose, and have lately been able to trace the use of it for decoration in ancient times, as I will describe.

The atmospheric condition of modern life in England, especially in towns, demands the use of a decoration of a permanent character, and the system of *cloisonnage*, of all materials for decoration, affords that sense of unity of effect so necessary in decoration, as its structure, while fully in evidence, enhances and assists the beauty of the work and does not detract from it. The division of colors by a line of neutral material, especially when of metal, is of the greatest artistic value, and blends and separates them at the same time; thus the contrast between the curved sinuous line and the field of color is most agreeable. The use made of it by the Greeks, and in the Persian friezes in the Louvre, is evidence enough of this.

I have been working on *cloisonne*, and using an encaustic filling.* The *cloisons* are usually about a quarter of an inch deep, and are soldered on to a metal ground, and the encaustic, hardened by the addition of 75 per cent. or more of marble powder, is pressed into the cells, and compressed into a hard mass, and finally polished down. Plates as large as 8 feet by 3 feet can be made by this method, and any degree of fineness or vigor arrived at. Plates can be placed side by side and so any extent of surface covered. The color is given by the addition of pigments, which permeate the mass of encaustic while being made.

But where encaustic is not suitable, other means of arriving at the result may be adopted; and with enamel, encaustic, glass inlay, cement, and *beton* of colored marbles, a range of materials is at hand to meet the exigencies of varying conditions. In some cases, the thin even line given by the *cloison* may be an objection, and in that case *champleve* would be substituted, or parts may be in one and parts in the other. As I have already shown, *cloisonnage* is an art with various renderings, and one has to use it with a proper discrimination of what is fitting for any given occasion. But this necessitates a long apprenticeship, and much unfruitful experiment, before sufficient experience has been gained; and advance has only been made by meeting a long succession of difficulties, many of which were technical and mechanical. Many more were questions of design and artistic treatment, and I have pleasure in acknowledging the assistance received by me from the criticisms of Mr. Frederic Shields and Mr. Starkie Gardner in dealing with these. In reviving an art such as this, one's knowledge grows from day to day; and I should like to say that even yet, whatever has been done does not demonstrate all that is possible, and must not be taken as a final expression of the art.

The facility for dealing with the metallic portions of the work has been largely increased by an association with Mr. Starkie Gardner's metal working and with the various means at our disposal. We are, therefore, again able to work on the lines suggested by the workers of the past.

HISTORY OF CLOISONNAGE.

EGYPT.

The history of *cloisonnage* begins on the banks of the Nile in the dim light of Egyptian civilization. When Athens and Rome were yet unbuilt, the arts of working in metal were known in the land of the Pharaohs, and thirty centuries before our era *cloisonne* jewelry appears to have been already perfected, and its use was continued through several dynasties. A statue in wood, found at Memphis, and said to date 3426 B. C., has the eyes laid in hard material and bronze lines. The mummy case of King An-Antef in the British Museum is similarly treated.



FIG. 1.—EGYPTIAN CLOISONNE JEWEL.

Cloisonnage, among the Egyptians, was made not only in gold, but in bronze, stone, porcelain, wood and ivory. The mere enumeration of the materials used shows that it held no isolated place in their art. It entered indeed into the decoration of many kinds of work, and must have been held in the highest esteem. The proof of this is found in the fact that it held the place of honor in the adornment of the dead. Nowhere were the dead so profoundly reverenced as in Egypt, where it was a current belief that the eternal existence of the soul, which so much occupied their thoughts, was connected with the conservation of the body. The ritual of the dead prescribed that certain ornaments should be placed with the deceased, and the pectoral was the chief of these. These pectorals remain in great number, and are in the form of hawks and other emblems, sometimes in *cloisonne* of gold, but mostly in *champleve* of less costly material; and these, after remaining in the darkness and silence of the tomb while the long roll of history was being enacted, are at last exposed to view in our collections. The finest of these are at Boulaq, where that found on the body of Queen Aah-Hotep, dated 1703 B. C., is one of the glories of the collection. Another of great beauty, found in the tomb of Rameses II., the oppressor of the Hebrews, is at the Louvre, and there is a gold hawk in London.

Besides the pectorals, bracelets, necklaces, etc., were made in *cloisonne*, and the kings are represented as wearing such. The fine pair of bracelets at the British Museum are in gold and *lapis lazuli* and blue lime cement, with figures modeled in low relief.

We find *cloisonnage* also worked in wood and ivory, which has been gilt. It was used for spoons, boats, and all manner of objects. There is a winged figure in Jermyn Street Museum, in wood, with inlaid wings.

The system was also extended to architectural decoration. The great hawks and winged lions over the entrances, as at Karnak, are cut out and colored in a way that produces a *champleve*, and the vertical colored lines, so often found on the cornices, are treated in the same way. It seems natural to suppose that these hawks, etc., were copied from the golden emblems in *cloisonne* jewelry worn on the person. And this the more that, in many examples, we find in the mummy cases at the British Museum scrupulously exact imitations in painting of the different kinds of *cloisonne* jewels formerly on the mummy within. The eyes, too, of the painted figures are certainly often copied from the inlaid bronze eyes found in some examples, and this explains their peculiar drawing.

I mention this particularly, because it is the first instance of the influence of *cloisonnage* on ornamental design, and this has occurred again in other times.

At the British Museum are also found parts of stone columns treated as a *champleve*, inlaid with colored porcelain, and two capitals are in bronze, which are true *champleves*, and have been inlaid with blue lime cement, part of which remains. These may have been parts of the light wood and metal architecture represented in paintings, and in which the design is just that suitable for *cloisonnage*.

It is evident, therefore, that in Egyptian art, the oldest art in the world, *cloisonnage* was deeply seated, and I think much of the technique of Egyptian drawing will be found to be due to the fact that the artist was thinking of inlay, rather than looking directly at nature.

The use they made of it for capitals and columns is suggestive of what might be done again. Mr. Aitchison said the other day, "We especially want to give the new materials employed, particularly iron, some vigorous stamp of architectural beauty;" and may it not be that by returning to the source which has already yielded so much, new ideas may yet be gathered, and that the masculine vigor of early art may yet have a lesson for us?

ASSYRIA.

If from the Nile we pass to the banks of the Tigris and Euphrates, we find the Assyrians and Chaldeans also making use of *cloisonnage*. Though the absence of tombs deprives us of any such record from actual remains as in Egypt, inscriptions supply the void in great measure. It is said to find these recount the ferocious cruelty of the monarchs, as well as their magnificence in decoration. We learn how captives were exposed before the great bulls and flung into the fosse, eaten by dogs, wild beasts and birds of prey, "to rejoice the great gods!" at the same time that we learn the magnificence and sumptuousness of the palaces. Mr. Charles de Linas, who has minutely investigated the history of *cloisonne* jewelry,* cites several inscriptions. It is recorded that in Chaldea statues were draped with gold incrusted with precious stones: and Mr. De Linas considers, as the result of his inquiry, that within the temples were plates of metal or stone, inlaid with figures in colored stones, and that the figures on the exterior in enameled bricks were copies of this inlaid work, the enamels representing the material employed—yellow, the gold; white, silver; red, cornelian; blue, *lapis lazuli*, etc. The drawing of these figures is such as to lead me to think any other origin than that of inlay is impossible. The semicircular frieze over an entrance arch at Nineveh, of which a drawing is given (Fig. 2), is an example of this.

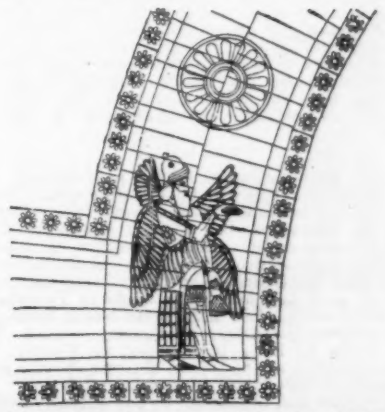


FIG. 2.—PART OF FRIEZE FROM NINEVEH.

The use of gold and precious materials was lavish; and this is the more easy to understand, when it is remembered that gold was valued in those early times precisely for its decorative qualities, and was not used

* A paper lately read before the Society of Arts, London. From the Journal of the Society.

* I was led to attach value to encaustic from the following testimonies: Linton writes—"So important was wax considered by the Greeks as the chief protector of their works of art, that the word 'wax' was frequently used to denote the picture itself. It was used mixed with resin."

Prof. Tingray writes—"Greece might still boast of the masterpieces of encaustic from the hands of Polygnatus of Thasos, had they not, after centuries of admiration, become the subject of envy to the Roman praetors, who caused them to be transported."

Montabert gives a list of colors which are not permanent in oil, but which can safely be used in a wax medium.

Sir Charles Eastlake writes—"The tendency of wax, when mixed with resin, is to check the tendency to glow when exposed to the highest natural temperature, and to prevent the cracking of the surface. Wax itself has no tendency to crack."

Mr. Standage said he considered the permanency of colors to be increased a hundredfold when protected by an encaustic medium.

And these opinions seem fully borne out by examples. Linton quotes the case of decoration in subterranean chambers, which were as perfect when discovered in the last century at Stabiæ as when executed, nearly 2,000 years ago.

Statues discovered on the Acropolis at Athens, in 1886, retained their painted ornaments in encaustic after nearly 3,000 years' burial. The color separated off from the marble when exposed to the air, but the pigment was still preserved.

Mr. Flinders Petrie has discovered, recently, at Hawara, many examples of encaustic painting, and he examined the history of its use. He says it has an advantage over oil, in that wax allies itself with all colors, and does not crack or flake off, and preserves the material on which it is laid against dust and damp.

The whole surface of the marble in buildings was covered by the Greeks with wax, to give warmth of effect, and this has had much to do with preserving the marble.

* "Les Origines de l'Orfevrerie Cloisonnee." A perfect storehouse of facts.

for money, and that stores of this metal were exacted from every conquered foe. An inscription (604 B. C.) mentions a cupola covered with gold, and a temple enameled and covered with gold.

Enamel is recorded as having been stored up in the royal treasuries as a precious substance, and it would be interesting to know whence this enamel came.

If, from the inscriptions, we turn to the remains, we find represented in the wall-carvings, jewels, dagger handles, and other personal objects, and the sacred tree—so designed that they could certainly be executed in *cloisonne;* and types of design, which would be natural for such work, are found in ornament, whether it be embroidery, painted work, or enameled brick. I cannot but think that here also, as in Egypt, the origin of much of the ornament is to be found in *cloisonne.* The records in the inscriptions of the use of metal, ivory, and precious stones in architectural decoration is quite in accord with existing remains, though, of course, little metal work has survived destruction.

MM. Perrot and Chipiez* show that wooden columns covered with metal were used in Assyria, and the volute is mentioned as originally being in metal. The only Assyrian columns discovered show a bulbous form of capital and base, in stone, evidently copied from a metal original, with raised *cloisons* as the only decoration. Place found remains of wooden shafts covered with bronze and gold scales.

Furniture was made in metal, and with great luxury, as in the Book of Esther we read of gold and silver furniture in the palace of the king. The bronze thrones, etc., at the British Museum, from Van in Armenia, show numbers of cells made in the bronze for the purpose of a color inlay, and ivory slabs were also let into spaces provided.

The stone pavement slabs under the entrance arches, which were of great size, were really a *champlevé* in stone. Three of these are in the Assyrian basement room. An examination of them shows the surface to have been cut away to receive a color filling, part of which still remains. M. Perrot considers the design of these more judicious and better conformed to the rules of art than the Roman mosaic. They are suggestive of the beautiful use which could be made of *cloisonné* for pavements at the present day. Two slabs were made in this way for St. Mary's, Stamford. Curved lines and the spiral predominate; and here, as well as in the painted work and enameled bricks, I infer, has been derived from metal-work.

I have now only to mention the beautiful ivories from Nimroud. They were found in great numbers, and often repeated, and must have formed part of the decoration of the halls. Part of these come from Phenicia and they are of the greatest interest in connection with our subject, because they are evidently a continuation of the Egyptian tradition, and are of *champleve* in association with relief. The spaces cut out have been filled in with *lapis lazuli* and other colors, and parts gilt, and the design is such as to suggest that they are derived from the metallic work. I shall refer to these again in speaking of Phenicia.

But before passing westward to Phenicia, it will be better to continue the history in the East down to our own time, as Oriental art has really continued much on its original lines, and has never lost sight of the true principles of polychromatic decoration. The East has been therefore a sort of reservoir of influence for Western art, which has again and again received a renewal of principles of decoration therefrom.

PERSIA AND THE EAST TO OUR OWN DAY.

After the overthrow of the Assyrians, the Persians kept up the traditions of enameling on brick, and it is to them we owe the grand series of works in low relief and enamel from the palaces of Darius and Artaxerxes Mnemon at Susa, now in the Louvre. One of these friezes is twelve yards long by eleven feet high, in perfect preservation, with a procession of archers in profile, and bands of ornament. Another is a frieze of lions, with ornament above and below. Mr. Aitchison says of these that "they have not only enlarged the mind of every visitor in the Louvre, and have given an almost unique lesson in monumental coloring, but have also given an impetus to that beautiful branch of art, enameled pottery. All the roofs of last year's exhibition at Paris were resplendent with color, wholly due to the exhibition of these enameled friezes."

Their effect is, indeed, of striking beauty—a harmony of soft blues, greens and yellows, with a little white and dark brown. The whole treatment is that of a *cloisonne,* the outlines being fillets of clay, separating the enamel, and reflecting lines of light.

Cloisonne jewelry was in use in the 3d and 4th centuries A. D., in the neighborhood of Perim, and appears to have been a survival of the Assyrian tradition. In any case the Græco Bactrian armlet at South Kensington shows the use of gryphons very similar to the old Assyrian type of winged figure. At the present day a beautiful form of *cloisonne* is used for belts and horse trappings in Northern Persia—silver *cloisons* set with turquoise. In modern Persia, *champleve* enamel has been in use, and in the tile work, as at Ispahan, the principle of *cloisonnage* is strongly marked.

INDIA.

In Indian art *cloisonnage* is fully in evidence. We find enamels of Jeypore of both *cloisonne* and *champleve,* and the lac-inlaid brass work from Moradabad is a *champleve* of a most beautiful kind. Jewelry is made of enameled *champleve,* and bowls and other large objects are also made in it at Kangra and Cashmir. A specially beautiful association of gold and enamel is made at Pertubghur for jewelry; saw-pierced gold plate being embedded on the clearest possible copper-green enamel. This system seems to have been copied in Venice. The Guthrie collection at the Indian Museum shows a series of examples of jade inlaid with gold and jewels. The work in copper and bronze shows the extensive use of the raised edge, and the same principle is carried into the architectural ornament. The resemblance between this and the Ionic Greek work is startling, and examination shows it is due to the principle being the same, while the design is different; the system in both being the use of a raised edge and concave surfaces. The Jeypore folio of architectural ornament fully illustrates this, and actual examples in the entrance court, especially the *facade* of a house from Bulandzhaha. Here we find, also, the use of pierced stone lattice work, which is so characteristic.

In Burmah the *cloisonne* principle is predominant, and the two cones from the palace show the actual use of *cloisonne* and gems. But the principle is so coarsely applied that it is of little further interest.

* "L'Art dans l'Antiquite,"

CHINA.

Passing to China, we find the principle has been introduced, and has struck deep root. It was perhaps imported with Buddhism from India, as *cloisonne* vessels were reserved for sacred uses. It was at its greatest development there about 1450, after which period it was somewhat neglected, but again came into favor under the Tai-thsing dynasty. The works of this period are paler than the earlier ones. It is said that one of the Emperors worked at it himself, as Louis XVI. did at lock-making. It was then entirely neglected, and was revived, through European demand, of late years, the traditions never having been quite lost.

JAPAN.

The Japanese received their tradition of *cloisonne* enamel through the Corea. While in India the tendency is to *champleve,* in China and Japan it is as much toward *cloisonne.* The oldest Japanese works are decorative and vigorous in character, dark in color, with green predominating. The *cloisons* are well marked, and the forms such as naturally arise in the bending of the metal lines.

Their modern work has been carried to a perfection which I do not think possible to be surpassed, and which, from a technical point of view, puts every other production of this work in the background. The delicacy is microscopic, and the mastery over the *technique* of the enamel really wonderful; but still we prefer the older works, and feel that the Japanese are losing the true value of the material, and, like the Limoges enamelers, seeking to make a purely decorative and ornamental art a vehicle of representation for which it is not fitted. On the other hand, they have worked out schemes of soft and neutral coloring which show what possibilities are latent in the system for modern use. The latest developments are the use of aventurine and a scheme of design on a blue-black background, which is one of the loveliest forms I have yet seen. This constitutes the present day development of traditions which commenced in Egypt nearly 50 centuries ago, and which have been in use ever since. The little Japanese we lately saw at work in London is a modern representation of the ancient worker on the Nile, whose ashes have long mingled with the desert earth, but whose works yet remain.

Returning west, to pick up the thread where we left it at Assyria, we find the Phenicians on the shores of the Mediterranean. They were allied with the Chaldeo-Assyrians by origin, and, as the great commercial *entre-preneurs* of the day, were in constant communication with neighboring peoples, and copied their art and that of Egypt, and spread these mingled traditions in the West in the course of their trading. One of their centers, Cyprus, was the meeting place of many currents, and here we find the art of Greece in contact with Eastern art. Di Cesnola has here found a *cloisonne* bracelet, and enameled filigree brooches of Phenician work. This bracelet is in the Egyptian style, but with an Assyrian element introduced. This one piece is sufficient to show that they made *cloisonne;* and the ivories found at Nimroud, as I have already said, suggest by internal evidence that they were designed on the lines suggested by the metal *cloisons.*

The Phenician stone capitals found at Cyprus, and illustrated by Perrot and Chipiez,* have motives borrowed from this ivory work, showing how stone forms were borrowed from the *champleve;* and again, a very early type of Ionic capital illustrated in the same work shows a transition from these Cypriote capitals, so that it would seem as if the Ionic capital is based through this medium on the *cloisonne* jewelry. A parallel case is the sarcophagus found by Di Cesnola, which shows a form of antefiscal ornament half-way between the ivory *champleve* and the later Greek form.

* "L'Art dans l'Antiquite." Vol. III.

THE HEBREWS.

It will be remembered that Solomon had Phenician workmen from Tyre when he was building the Temple. From the fact that the Phenicians used *cloisonnage,* we may infer that it would probably be used in the Temple; and from the descriptions, and from the fact that the Hebrew word translated "carve" means to cut or engrave (Smith's "Dictionary of the Bible"), in the accounts given, I am led to think it certainly was used there; but as no remains exist, it would take too long to pursue speculations on this subject.

GREECE.

If we pass across the Ionian Sea to the sunny land of Greece, we find evidence of the *cloisonnage* system being known to the Greeks. In the archaic work of Mycenæ and Tiryns the peculiar spiral ornament found on the stone pillar at Mycenæ and other places, which Fergusson regretted we did not know more of, has now had its origin cleared up by the discoveries of Schliemann. It is evidently a copy in stone of a purely metallic ornament.

Mycenæ was a powerful fortress on a rock rising out of a level plain, and the royal residence of a warrior race, who loved architectural beauty and personal adornment. Armor, weapons, and utensils were of precious material, the most delicate and graceful workmanship. The palace was rich in color, bronze, and alabaster.

The tombs of the royal occupants have held the treasures now well known, which are largely of gold and bronze, and here we find the spiral lines and raised edges from which the ornament on the stone work was derived. A scepter in *cloisonne* of gold, inlaid with rock crystal, was also found.

The timbers of the buildings and the doors were incased with plates of bronze, and slabs of alabaster, inlaid with glass and richly carved, decorated the vestibule at Tiryns. Metal plates were also used to cover the vault of the tomb of Attrius and others. It is generally admitted that early Greek work was largely metallic, and the descriptions in Homer refer to the use of metal decorations. This metal led to the use of an edge rather than to relief.

In the fully developed Greek art we find the goldsmith's work still carrying out the same idea. It is of filigree work and *repousse,* with enamel color used with the greatest restraint, and just enough quantity to give contrast to the gold. The work is so refined and beautiful, so right in scale compared to the human figure, that one cannot imagine it to be surpassed; and we can guess what it must have looked like when adorning some lovely Greek. In later work this restraint and refinement disappear. Enameled filigree is still made by hereditary Greek smiths, who have kept up the tradition of the ancient Greeks.

The bronze work shows the constant use of an edge in contrast with broad rounded surfaces, and damascening with silver and gold.

If from the metal work we turn to the Greek architectural ornament, we find the same feeling prevailing. I have already mentioned the Ionic capital and the antefiscal ornament. In Ionic work, as at the Erechtheium, we find further evidences of the *cloison* principle. The plaited moulding of the capital was inlaid with

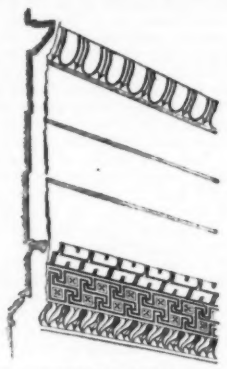


FIG. 3.—GREEK ENTABLATURE SUGGESTING CLOISONNE TREATMENT.

colored glass, as shown by Hittorf. The whole of the carving shows the use of the edge, as, for instance, in the frieze, where the flower ornament is an edge about half an inch wide, on a sunk ground, and this edge is again grooved on its surface, so as to produce yet other lines. The same character marks the egg and dart, and other mouldings above the frieze. If these were gilt, and the background colored, as seems was the case, the effect would have been that of a *cloisonne,* full of sparkling light and color.

In Doric work the painted ornaments on the moulding are, in design, quite a *cloisonne.* I have drawn out full size mouldings from the Propylæa and the Parthenon; from data given by Mr. Penrose in his work, and a part of the ceiling design, and it will be seen how the sumptuousness of the color* is still full of grace and refinement, due to the gold dividing lines. These colored parts, far from hiding the beauty of the marble, would add to it by contrast. Whatever may be thought of Greek polychromatic decoration, which has been the subject of so fierce a controversy, one thing is certain, that they did use color at the finest period, and they designed it on the principles of *cloisonnage.* If at a later time they discontinued it, it was contemporaneously with a decline in their art.

All through Greek work the edge seems to be used in contrast with the broad surfaces, and I cannot but think the Greek artists were fully conscious of the value of this system. The flutings of columns, the mouldings, and even the drapery of the figures (which is raised into ridges and deep grooves) all carry on the same idea. Mr. Elsey Smith says, "One can still sit in front of the Propylæa at Athens, and watch the sun as it creeps round, gradually bringing out new lines of light."

If this is so, does it not offer suggestions for our Renaissance work of to-day? For instance, may not the concave treatment be the right treatment for carved work for our London atmosphere? Relief work requires to be clean, and to have a fairly good light to be readable; but edge-work, no matter how dirty is the surface, how dull the light, will hold its own. Evidence of this may be seen by a comparison of the carved panels in the Foreign Office and Treasury. It is remarkable that, while particular *motifs* of Greek ornament have been copied *ad nauseam,* the principles on which the Greeks worked their ornament should have been so little used.

And, again, in the interior of large public buildings, where the relative value of colors must be soon destroyed by dirt, and made to approach uniformity, how greatly it would enhance and preserve the effect if the system of design were based on *cloisonnage,* so that a delicate weaving of gold lines through the whole would remain long after the purity of these colors was lost, and render the whole intelligible.

And bands of *cloisonne* could be used in conjunction with marble as suggested by the mouldings of the Propylæa. The use of *cloisonne* with sculpture as a means of introducing color without loss of preciousness is suggested by the colored bands of the Parthenon.

I must now briefly continue the history after the Greek epoch.

ROMAN.

In Roman work, we come upon a gap in the history. For the first time, so far as I know, in the history of art, the edge system is lost, and gives place to rounded relief ornament. There is consequently a marked contrast between Roman and Greek ornament. May the explanation of this be found in the fact that hitherto architectural ornament had been mainly flat polychromatic work, used in association with figure relief, and that under the Romans color and figure ceased to be generally used? However, traces of the *cloisonnage* system still remain here and there, as at Pompeii, where large numbers of borders are based on a type of design formed of yellow lines on some dark

* The medium used was encaustic, a mixture of wax and resin. The red pigment was oxide of iron; the blue, carbonate of copper; the white, carbonate of calcium (chalk); the dark green, Verona earth.

color. Mr. Gardner showed us the other evening that quite important pieces of *champleve* enamel were made for the Romans by the British, which goes to show that the Romans appreciated it when it was put before

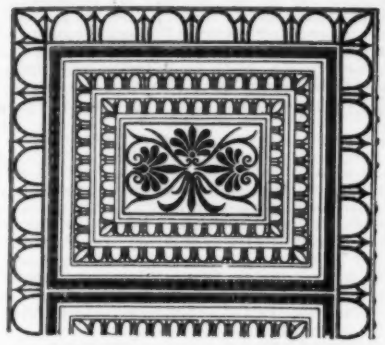


FIG. 4.—PART OF POMPEIAN CEILING.

them, and large numbers of examples of Gallo-Roman *champleve* have been found.

BYZANTINE.

The subject of Byzantine art has just been taken up by Mr. Aitchison, who has pointed out the enthusiasm with which the buildings were erected, and the luxury and riches, in the form of gold, and silver, and precious stuffs, which were lavished upon them. Procopius says that 40,000 lb. weight of silver was employed in the sanctuary of St. Sophia, and the Ambo, of rare marbles, was enriched with precious stones and ornaments in enameled gold; and the dome roof was of gold enriched with gems. If to all the luxury of material we add the Asiatic love of color, and the employment of Greek workmen and traditions, we shall not be surprised to learn that *cloisonnage* again found a fertile soil. Sculpture being disallowed, *cloisonnage* and mosaic came to the front: and it is here first of all we find an extensive use made of *cloisonne* enamel. The paliotto of St. Sophia is said to have been decorated in this work; and a little piece, stated to have been a part of this, is in Jermyn Street Museum. Though the bulk of all this work has disappeared, a fine example remains—the Pala d'Oro, at St. Mark's, Venice, which was ordered originally for Doge Pietro Orseolo, at Constantinople, in 976, though it was subsequently enlarged and altered. There are other works in *cloisonne* enamel which have been probably brought from St. Sophia with it. Its value is said to be £160,000.

It is now in three divisions, one above another. The lower one, with Christ and the Virgin Mary in the center compartment; on either side the Doge Ordelafo Faliero, and the Empress Irene, and the prophets on the outside of these. In the second division is Christ blessing, with apostles on either side. In the third a figure of an angel, flanked on either side by scenes from the life of Christ. In all there are 83 panels of *cloisonne* enamel in gold. M. De Verneilch says that when in use, the effect of it is of the greatest beauty, the light reflected from the thin and numerous *cloisons*, etc., eclipsing the mosaics. "With its innumerable figures drawn in lines of fire, and tinted with glowing colors, it is a striking example of the *role* which enamels can play in the decoration of religious monuments."

Cloisonne jewelry for personal use also seems to have been made, the *cloisons* always being very thin, and the enamel very clear and bright. *Champleve* does not seem to have been used at all.

As in the case of the Egyptians, the use of *cloisonne* in their most precious monumental works set the taste for other things, and we find the silks and textiles made under Byzantine influence echoing this work. The use of gold, and color, and lines dividing colors, is often the basis of design.

The MS. illustrations are manifestly inspired by the enamel work, as in the MS. in the Imperial Library at St. Petersburg. The mosaic in the principal nave of St. Galla Placida, Ravenna, is quite a *champleve* in effect; and the mosaics at Palermo show a general lininess of treatment. The works of Torriti, in the Basilica of St. Jean de Lateran, show a similar use of white dividing lines, and suggested to Mr. Gerspach a Persian faience.

The Byzantine carving is nearly all worked on the edge principle, notably the ivory work. The use made of *cloisonne* by the Byzantines suggests especially panel decoration for the introduction of colors in frontals, pulpits, and the like. Sketches of works executed for St. Mary's, Chester; St. Luke's, Cork; the Harrow Mission Church, Latimer Road, etc., show how this can be done.

RUSSIA (GREEK CHURCH).

The Byzantine traditions seem to have continued down to our own time, in the Greek Church of Russia, though modified by Asiatic and Renaissance influences.

Metal work and enamel hold the principal place in Russian art, though, unfortunately, little remains anterior to the 17th century. But from this date a rich collection exists, and the use of *cloisonne* and enameled filigree is abundant, and is the principal characteristic of the work. It is, however, used without reserve, and though the effect is rich and gorgeous, it is not very satisfying after the finer works of other times.

It was applied to most varied uses, decorating images or pictures, lockets, crosses, vases, book covers, lamps, chrisms, and other church furniture. The imperial crowns, the imperial orb, shoulder plates, and other ornaments of the royal robes, the scepter, and the thrones are all wholly, or in part, *cloisonnage*. Damascene work is also prevalent in armor. Shields, scabbards, bow cases, and armor are also treated with gold and enamel.

The collection of Russian enamels at the British Museum gives an idea of the effect of this work.

MORESQUE.

We must remember also that Saracenic art was largely based on Byzantine art, and here, whatever else varies, the use of a gold line to divide color is constant. The decorations of the Alhambra, for instance, are all based on this, and it is because of this that such



FIG. 5.—MONUMENTAL STONE FROM THE CHURCH OF ST. GENEVIEVE, PARIS.

infinite complexity and richness have been attained, without losing a sense of chasteness and repose.

MEDIÆVAL.

The history of the Rhenish Byzantine and mediæval schools of enameling is comparatively well known, and I will only insist on the fact that until a decadence of taste set in, enamel was used in the form of *cloisonne* or *champleve*.

Byzantine enamel is associated principally with filigree, the Rhenish with chased work, as in the reliquaries of Cologne and Aix-la-Chapelle. The contrast of the delicately wrought metal and the rich color is extremely beautiful. French work is, artistically, much coarser, and more reliance is placed on enamel as an end in itself.

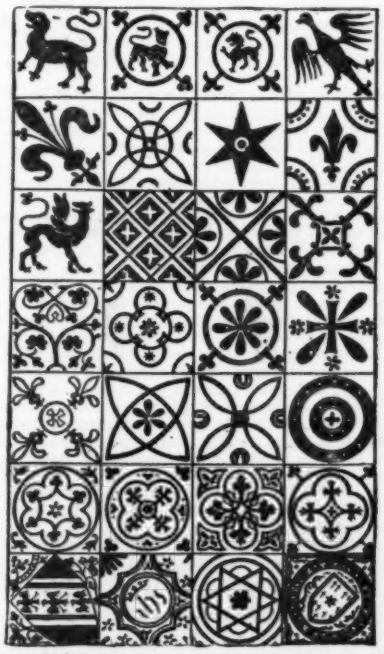


FIG. 6.—PAVEMENT TILES ILLUSTRATING CHAMPLEVE WORK.

Goldsmiths' work and enameling appears to have been, about the 12th century, the art most in repute, and was most extensively used for princely presents, for monumental purposes, and for the adornment of all sorts of sacred objects, and its influence must have been great in setting the taste in other arts. I cannot but think that the cultivation of this art gave origin to much that is not generally connected with it. There seems no doubt that painted glass grew out of it. Painted glass appears first in the vicinity of Limoges, about 1100, and the earliest glass known to exist, that of Le Mans, bears internal evidence of its origin. The drapery of the figures is drawn in a way foreign to painted work, but such as would be the natural outcome of cutting spaces out of copperplate for enameling, and the borders of early windows, and the ornament generally, is just of the character found in *champleve* enamel. In a few years all trace of this enamel-like drawing disappears.

So, again, much early Gothic carved ornament in stone points to an adaptation of the gold filigree work used with enamel, as in the reliquary at Aix-la-Chapelle.

Again it is evident that memorial brasses are derived from *champleve* enameling, as, though they generally are rather in intaglio, many examples exist of parts, as of armorial bearings, etc., with the whole ground cut away and filled in with color, so as to produce a real *champleve*.

While the brasses are well known, the stone slabs which were also largely used are less remembered. They are *champleve* work in stone, and in some cases metal *cloisonne* is associated with this, as, for example, in the memorial slab of Fredegonde, formerly in the church of St. Germain-des-Pres at Paris, and another of the Bishop Frumauld. The main lines of the design are marked by stone *cloisons* of some width, and subordinate divisions are made in brass, and the color obtained by a colored *beton*. Later examples, as that from the church of St. Genevieve, Paris (Fig. 5), and another in the cathedral of St. Omer, are *champleves* in stone, filled in with black and colored mastics. These evidence the appreciation of this kind of inlay by Gothic artists, and offer suggestion for memorials to-day.

For memorials, the use of bronze is evidently of great advantage, as it is unbreakable and imperishable, and being of a different material from the building where it is used, greater liberty of treatment is allowed than would be the case with stone or marble. But it is of itself apt to look heavy and dark, and this defect the use of color by means of *cloisonnage* removes.

The color is added without any loss of preciousness, and this practice can be extended to statuary and relief work.

There is a good deal of pavement work at St. Omer, of marble inlaid with colored mastic, and this work, it has been supposed, gave rise to the "Norman tile" work, or encaustic tiles in clay, so much used in England, which are, in fact, a *champleve* in earthenware.

While in the 14th and 15th centuries *cloisonnage* is lost sight of in the Gothic work, the association of gold lines is found extensively in Gothic MS. illustrations.

I have no need to insist further than was done the other evening by Mr. Starkie Gardner on the art having been practiced in England, but it is interesting to accentuate the fact that, here in London, *cloisonne* was being made in Saxon times, and that some of the pieces are at the British Museum to-day.

As to Irish work, not only was *cloisonne* enamel used, but this with the filigree seems the basis of the interlacing spiral ornament in the MS. drawings and elsewhere in Celtic work, which has sometimes puzzled archæologists to account for.

RENAISSANCE.

I have, finally, to say a few words of the Renaissance period.

In Renaissance work—founded upon the Roman classic—we find no tendency to a *cloison*-like treatment. Everything tends to relief. And, even in the polychromatic ornament, as at Mantua, etc., relief work is the "*motif*," and color has to fit in as it can, and, consequently, is rather a "fifth wheel," as the French say.

But, in French Renaissance, we find another type of design; and here the *cloisonnage* system is pervading. This is easily explained. Much of the French Renaissance came through Venice, and Venice was exposed to Oriental influence. Many of the Venetian book covers are scarcely distinguishable from Persian exam-



FIG. 7.—ENAMELS FROM THE RELIQUARY OF LIMBOURG.

ples. We know how the Venetian bookbinding was brought into France after the Italian wars by Grolier, and, through him, taken up by the court; and this in itself may have done much to introduce the interlacing patterns so much in vogue in the time of Henry II.

It is because early French Renaissance is pervaded with an Eastern spirit that the principles of *cloisonnage* are so marked.

In early French Renaissance, book covers, enameled jewelry, textiles, painted decoration, and especially *applique* embroidery, all show this Eastern influence. Enameled jewelry was abundantly produced, until

it commenced to decline, when Louis XIV. sent his plate to be melted up in 1688. A peculiar kind of *cloisonne* was made in France for watch covers. It seems to be a continuation of the Pertubghur method. Several examples are at the British Museum, and designs for this work, by Philip Nolin, are extant.

We find the same feeling in England under Elizabeth and James I., but, of course, in a coarser and heavier expression. In Germany enameled filigree was much used.

As the impetus of the Renaissance died away, the system of *cloisonnage* completely disappeared; but now that there is such a strong tendency toward early Renaissance, this, as a part of it, should be brought forward again. And it is especially adapted for fireplace decoration.

We have now reviewed the work of long centuries, and the arts of many nations and climes, though the list is far from complete, and we have seen *cloisonnage* pursue its way from the dawn of civilization in Egypt to the present day.

It has always been regarded as something precious, and it has been associated with sacred and royal use, and especially for monumental art. The Pharaohs of Egypt; the warrior kings of Mycenæ; the Sargonidæ of Assyria; Darius and Xerxes; the noble ladies of Greece; the Byzantine and Hungarian emperors; our English kings, Saxon and Norman; Charlemagne; the line of Russian czars; Henry II., and Queen Elizabeth are among those who have all, one way or another, used this art; and who shall number the potentates of the great and mysterious East who have glorified themselves therewith? In architecture, the temples of Egypt, the palaces of Assyria, the temples of Solomon, of Ephesus, of Athens, of Olympia, of Pæstum and Metaponte, and numbers besides, have felt its influence; and, in later days, the sanctuaries of Byzantium, Venice, Aix-la-Chapelle, Paris, and Westminster, and numberless others have been enriched by it.

Can it be considered then a barbaric and trivial art? If so, then is all decoration barbaric, for *cloisonnage* has flourished at the epochs and among the people whose arts we copy and admire, when decorative design

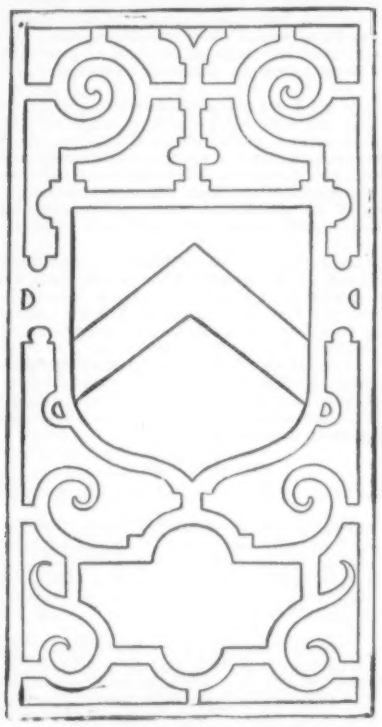


FIG 8.—ELIZABETHAN ORNAMENT SUGGESTING CHAMPLEVE.

was at its highest; and it has fallen out of use when beauty of line and beauty of color were no longer appreciated for their own sake, and artists were forced to lean on some form of imitation or fantastic design.

But we live in a time when walls are not covered with gold or bronze, but with advertisements; when enamel, stored up as a precious substance in Sargon's treasury, is turned out in unlimited quantity, and dedicated to the rival glories of soap and mustard. The ideal of life is cheapness and not preciousness, and bigness rather than beauty; but, above all things, *cloisonnage* has ever been valued for its preciousness and its beauty, and its use will therefore be limited to special occasions.

The paper was illustrated by drawings and specimens lent by the Science and Art Department, as well as by drawings and specimens exhibited by Mr. Heaton.

THE EFFECT OF INVENTION UPON THE PROGRESS OF ELECTRICAL SCIENCE.*

By Prof. C. F. BRACKETT.

ELECTRICAL science really begins with the labors of Dr. Gilbert. These he published in 1600. For almost exactly two hundred years investigation was confined to that domain which is still sometimes called static electricity. A new era, however, dawned in 1800, when Volta gave to the world an invention whose importance can scarcely be exaggerated—the voltaic battery.

The simplicity of the device and the wonderful effects which it could produce at once excited the most lively interest, and men of science made haste to investigate it.

By means of it Carlisle and Nicholson soon succeeded in decomposing water, and Ritter had a similar success with copper sulphate. Thus commenced a long line of research in electrolysis, which was pursued with great success by Davy and others, and which finally led Faraday to the grand generalization known as Faraday's laws of electrolysis.

Meanwhile Ritter had noticed that the two plates of the same metal which have just served to convey the current to and from a liquid while undergoing electrolytic decomposition can, of themselves, furnish a current, and he was thus led to the invention of the "storage battery." It was Volta, however, who gave the correct explanation of its action.

Ritter, Plaff, and others, observed that the conducting wires of the battery are warmed by the passage of the current, and Curtet, on closing the circuit with a piece of charcoal, produced a brilliant light. Davy systematically investigated these heating effects of the current, employing various metals as conductors, and finally in 1812, on making the current pass between two pieces of charcoal, he produced the well known arc.

Thus, in little more than a decade from the date of Volta's invention, more real progress was made than in any century previous. But the true progress of electrical science is not to be measured solely, or even mainly, by the number nor by the splendor of the physical results which attend it, but rather by the insight into the operations of nature which we gain. Viewed in this light, Volta's invention was itself the embodiment of a great advance which he had made into an entirely new region. It was not the mere outcome of happy accident, but the result of severely logical reasoning upon facts which he had observed while he was investigating the so-called "animal electricity" of Galvani.

Volta's fundamental research respecting the electrical disturbances produced by contact of dissimilar substances afforded him a basis for a rational theory of the action of the battery, and this theory has had a far-reaching influence, not only upon the progress of electrical science, but on physical science in general.

The voltaic battery rendered possible an observation out of which grew the next great invention which we will consider. In 1820 Oersted noticed that a magnetic needle was deflected from its normal position by a voltaic current, which was flowing in a conductor near it. He determined the relation of the current to the deflection as respects direction, and sent a brief memoir concerning the matter to well known scientists.

Arago immediately found that iron filings were attracted by a wire conveying a voltaic current. In order to strengthen the magnetic action of the current, Schweigger invented the magnetizing helix or spiral. By means of this Arago was able to magnetize steel permanently and iron temporarily.

The conception of this helix was the first act of invention which was to produce the electro-magnet. Yet it was not until 1825 that Sturgeon wound a conducting wire about a core of iron to produce the electro-magnet proper. The magnet, as it left the hand of Sturgeon, was a crude device, which the genius of Henry finally perfected between the years 1828 and 1831. Henry constructed several magnets, some of which were wound with long, thin insulated wires, while others were wound with shorter and thicker wires in parallel. These could be joined either in series or in parallel. He thus had the means of studying the effects which a given battery can produce when made to actuate magnets having different windings. He also investigated the effects which are produced by the use of batteries having different electro-motive forces. He thus discovered the principles which must be observed in order to secure the best results from the electro-magnet under any given conditions.

Indeed, a careful examination of Henry's work will convince one that he disclosed the same result by the light of skillful experiment as is set forth in Ohm's now well known formula. Moreover, he clearly perceived that the magnet, as he had perfected it, offered the solution of the problem of the telegraph, and he made proof of his prevision by actually installing one.

In the hands of Ampere the conducting helix was made, under one form or another, a means of investigation which he pushed with wonderful energy and skill until he unfolded the laws of interaction between magnets and electrical currents, as well as those which govern the mutual actions of the currents themselves. In short, it may be said that as the result of his inquiries, Ampere was brought to a comprehensive theory of magnetic action which was startling alike for its simplicity and its boldness. It deserves to rank with Newton's theory of universal attraction.

The skillful labors of Faraday and Henry brought to light by the same means the laws of induced currents, and so supplied the elements which practical inventors have since combined so as to do our bidding, whether it be to illuminate our streets and dwellings, push our cars, or delve in the mountain for hidden treasure.

The electro-magnetic phenomena educed by the voltaic current as it flows through a helix constitute the basis of a most admirable system of measurement for electrical quantities, while the helix itself contains, in germ, the whole family of measuring instruments by means of which such measurements are made. Moreover, these phenomena led the sagacious mind of Faraday to a wholly new way of regarding electrical action in general.

He clearly perceived that the old doctrine of the "imponderables" was untenable, and he looked for some common nexus between all physical actions. He was disposed to refer the interactions which bodies exhibit in consequence of their electrical states to the medium intervening between them. As light is believed to be transmitted by a universal medium, he sought to find, by experiment, some connection between light and electro-magnetic action. On passing a beam of plane-polarized light through a block of glass within a magnetizing helix, he found that the beam was twisted when the current was made to flow through the helix.

Maxwell undertook the very important work of subjecting the results preached by previous workers, and generally set forth in Faraday's "Experimental Researches," to mathematical discussion, which must be considered the final test of truth.

Not to mention others, one very important result was his "electro-magnetic theory of light." But experiments were wanting, save the single one of Faraday, just mentioned, to confirm his deduction. It was reserved for Hertz to supply the necessary evidence in support of Maxwell's theory, which he has lately done by making skillful use of the oscillating discharge of charged conductors, earlier demonstrated by Henry.

Thus it appears that the two great germinal inventions which have most influenced the progress of electrical science during our century are the voltaic battery and the magnetizing helix. The one gave us first the means of evoking electrical energy continuously while the other gave us the means of applying it as we might have occasion. Both contributed powerfully in a direct way to the progress of electrical science, by reason of the various and startling phenomena which they revealed.

But it seldom happens that progress continues long in any department of physical science unaffected by the practical application of its results in the arts, and, conversely, such applications almost invariably react to stimulate scientific inquiry. Two principal reasons for this effect may be noticed. When the apparatus and the operations of the laboratory give place to those which are suited to commercial uses, new conditions arise which frequently bring into prominence phenomena before unobserved or inconspicuous. These then become subjects for new investigations and in due time scientific progress is the result.

Thus telegraphy brought its knotty problems as well as its successes, especially when its lines were stretched under the sea and when one wire was required to do the duty of several, and nothing less than the highest skill and the most severe analysis has sufficed to effect their solution.

So, too, telephony was early beset with peculiar difficulties, notwithstanding the simplicity of the means which it employs, thanks to the genius of Professor Bell; but they were such as electrical science has profited from. Speaking generally, it may be said that almost every one of the devices which are in daily use for the transformation of mechanical work into electrical energy, and the converse, has compelled its inventors, in the course of its evolution, to contribute something to the common stock of scientific truth.

It was regretted by Franklin that the results of electrical research had not been turned more to the use of man in practical affairs. Faraday did not doubt that the time would come when that reproach would be removed, but he felt that it was a duty on his own part to push on the work of discovery, and to leave industrial inventions to others. Such applications are now everywhere about us and are rapidly extending. Of course they involve the investment of millions of capital, and this renders it impossible that the great public shall be indifferent to the science upon which they depend. Hence it is that all our schools of technology and most of our colleges have already made provision for training in it.

Every consideration leads us to expect that future progress in electrical science will be more rapid than it has ever been in the past; the present offers to the student the accumulated treasures of knowledge and the hope of scientific distinction as well as that of pecuniary reward. It can hardly be that among the scores of young men to whom these advantages come as inspirations, there will not be found some who shall prove to be worthy successors of the great men into whose labors they so easily enter.

INDUCTIVE DISTURBANCES IN TELEPHONE CIRCUITS.*

By J. J. CARTY.

IT was not known until 1838 that the earth might be used instead of a return wire in the circuit of a telegraph line. This fact was discovered by Steinheil while making experiments to determine whether a track of a railroad could be used to complete the circuit instead of a return wire. Steinheil's discovery has been considered as one of the most important in the art of telegraphy, and since his time it has been the almost universal practice to use the earth as a return in telegraph circuits. When, however, the earth return is used with the telephone, it is found that owing to the extreme sensitiveness of that instrument many foreign currents which would produce but little effect on telegraph instruments become a source of serious trouble. For this reason, in telephony it is often necessary to use a complete metallic circuit. Thus it has come to pass that a return to the original practice of employing metallic circuits, as in the case of the crudest telegraph instruments, is now regarded as a most important improvement in connection with that most highly developed of telegraph instruments—the telephone.

To obtain complete freedom from inductive disturbances in the telephone, it is necessary not only to use a metallic circuit, but to place the two wires composing the circuit in a special relation to the source of disturbance. One of the methods of so arranging the wires is shown in Fig. 1.



Fig. 1.

In this case the two sides of the circuit, L^2 and L^3, are twisted spirally about each other, so that their average distance from the disturbing wire, L^1, shall be the same. With such a plan, the telephones, *a* and *b*, are not affected by induction from the wire, L^1. This fact has usually been explained by assuming that a current, commencing to flow in L^1, tends to induce two currents in the opposite direction to itself, one in the wire, L^2, and the other in the wire, L^3; that both currents are of the same strength, because the average distance of L^2 and L^3 from the disturbing wire, L^1, is the same; and that the telephones, *a* and *b*, are silent because they are acted upon by two equal and opposite forces. The above theory seems at first sight to be correct, and indicates the line of explanation adopted in many works treating of the subject.

I have made a number of experiments which seem to prove that in the case described the inductive action, instead of tending to produce a simple current in each side of the metallic circuit, actually does produce a number of different currents in each wire and in both directions.

* A paper read at the Patent Centennial Celebration, Washington, April 8, 1891.

* Read before the American Institute of Electrical Engineers, New York, March 17, 1891.

In Fig. 2, L^3 and L^3 are two well insulated copper wires, 500 ft. long and three feet apart. These wires are joined together at each end through an ordinary telephone. L^1 is a well insulated wire, similar to the other two, and placed within one-half an inch of L^3. At one end of L^1 is placed a Blake transmitter, T, and

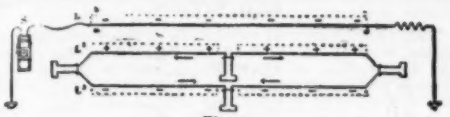


Fig. 2.

at the other end is placed a subscriber's bell, S; L^1 being grounded at both ends, as shown. When the transmitter, T, is operated, either by speaking into it or by vibrating a powerful tuning fork in front of it, disturbances are produced at the end telephones.

If telephones are inserted at the center of L^3 and L^3, it is found that at those points no sound is heard, while the noise of the end telephones continues as before. This constitutes a simple case of inductive disturbance, and can only be explained assuming that the wire, L^1, acts electrostatically upon the circuit composed of L^3 and L^3, or in other words, that we are dealing with a system of condensers in series, of which L^1 constitutes one plate, the earth another, and the wires, L^3 and L^3, two intermediate plates which are joined together through the end telephones.*

Let us assume that at a given instant the height of potential along the wire, L^1, is represented by the lines, *a b* and *c d*, and the charge upon L^1 by the rectangle, *a b c d*. The presence of this charge, which we will say is of the minus sign, is accompanied by an equal but plus charge on L^3. This produces a minus charge on the wire, L^3, which in turn acts upon the earth. Now, we will assume that the potential on L^1 is reduced to zero. This causes a restoration of the equilibrium in the circuit composed of L^3 and L^3 which is accompanied by a set of currents as represented by the arrows. The plus charge on L^3, flowing through the end telephones, neutralizes the minus charge on L^3, thus leaving a neutral point at the center of each of the wires, L^3 and L^3.

In this and the succeeding experiments the induced charges are represented by rectangles. This is not a strictly accurate method, but as an error in this respect only affects the result quantitatively, and cannot alter the conclusions, I have adopted it on account of the simplicity of treatment which it permits.

The potential along the wire, L^1, at a given instant is represented as being constant, as it is found that owing to the high impedance in the instrument, S, there is practically no fall of potential in the wire itself. Furthermore, it was found in the experiments about to be described that the results were the same whether the disturbing wire was open or connected to earth through the bell, S. There would be a fall of potential along the wire, L^1, if it were of such a length as often found in practice, and the distribution of the charge would be modified accordingly. But as this fact would only affect the location of the neutral points, the question of the fall of potential will not be taken into consideration and the disturbing wire will be shown open at one end.

Fig. 3 shows the same circuits as used in the previous experiment, except that the wires, L^3 and L^3, are

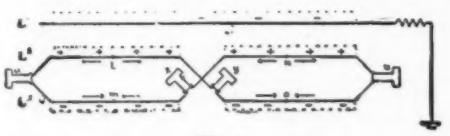


Fig. 3.

caused to change places at their centers but are continued in the same plane as in Fig. 2. This is what is called a "transposition." The telephones at the ends and in the middle are retained as before. Under these conditions, when the transmitter is operated, a diminished sound is heard at *a* and *b*; and *x* and *y*, instead of being silent, as in the first case, now emit a sound of the same intensity as *a* and *b*. When telephones are placed at the quarters, *l*, *m*, *n*, *o*, the sounds at *a* and *b* and *x y* continue as before, but nothing is heard at *l*, *m*, *n*, *o*. The effect of this one transposition has been to reduce the disturbance at the end telephones, *a* and *b*, and to cause a shifting of the neutral points from the centers to the quarters, and an increase of their number from two to four.

An examination of the induced charge shows how these results have been brought about. It will be seen, by reference to Fig. 3, that there is on the first half of L^3 a positive charge, and on the second half a negative charge, and on the first half of L^3 a negative charge, and on the second half a positive charge. When the positive charge on L^3 discharges, half of it goes through the telephone, *a*, and half through the telephone, *y*. The positive charge on L^3 escapes in a similar manner, half going through telephone, *x*, and half through telephone, *b*. This produces four currents, two starting from point, *l*, and two starting from the point, *n*. One of the currents from *l* meets a current at *o*, coming from the point, *n*, and one of the currents starting at the point, *n*, meets a current at *m*, which started from *l*. The currents flowing through the end telephones in this case are not so strong as when no transposition is employed, because they are due to an induced charge which is represented by an area half as great. It is found that as the number of transpositions is increased the number of neutral points is also increased, and that the area representing the charge, which escapes through the end telephones, is reduced. To obtain silence, therefore, it is necessary to increase the frequency of transpositions until the discharge through the end telephones is so small as not to produce sounds therein.

Fig. 4 shows a circuit containing three transpositions, one at the center and one half way between the center and each end. In this case, if we could neglect the resistance of the telephones, the current going through the ends would be reduced to one-fourth of its original proportions, and eight neutral points would be produced, one in each wire at the center of each transposition.

In practice, the impedance of the telephones must be taken into consideration, so that if, in Fig. 3, the middle telephones *x* and *y* were omitted, the neutral points would be found to move toward the ends, and the currents flowing through the end telephones would be correspondingly reduced.

According to this theory of transpositions, if the instruments and distances between wires on a given circuit remain constant for a given period of alternations in the disturbing wire, the number of transpositions necessary to obtain silence will depend on the



Fig. 4.

E. M. F. of the disturbing wire and the specific inductive capacity of the dielectric. An increase in the value of either of these factors will, if silence is to be maintained, require additional transpositions, their number depending upon the value of the change which is made.

Where the disturbing wire is placed at an equal distance from both sides of a metallic circuit, no noise is produced in telephones located in that circuit, and a balance once being obtained, it is independent of both the E. M. F. of the disturbing wire and the specific inductive capacity of the dielectric.

Fig. 5 shows such an arrangement of circuits—L^3 and L^3 are the two wires composing the metallic circuit placed the same distance apart as before, and the disturbing wire is at an equal distance from both. When the disturbing wire is in operation, no sound is heard at the end telephones or at telephones located at the centers. This may be accounted for by assuming that

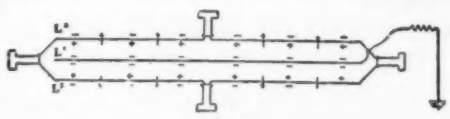


Fig. 5.

at a given instant a negative charge is on the disturbing wire, which produces a positive charge on the inside of L^3 and L^3 and a negative charge on the outside of those wires; and that when the charge is removed from the disturbing wire, a set of currents is set up in the wires, L^3 and L^3, in a direction at right angles to their axes, as shown by the arrows. In this case the flow is lateral, and no current passes through the end telephones or through telephones located at the centers. It will thus be seen that this method of arranging wires differs essentially in its action from the plan of using transpositions. Unfortunately, however, its practical application is limited to two circuits.

Where the disturbing wire occupies the position shown in Fig. 5, the flow in the conductors is lateral only when the wires, L^3 and L^3, are insulated from the earth. If a ground be attached to the center of L^3, as shown in Fig. 6, the flow of current becomes longitud-

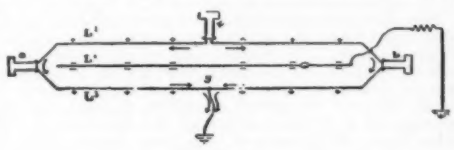


Fig. 6.

inal, and the telephones, *a* and *b*, are found to be affected by loud disturbances, while the telephone, *x*, at the center of L^3, is found to be silent. This is because the disturbing wire, which we will say is negatively charged, induces a positive charge upon L^3 and L^3 and a negative charge upon the earth. The discharge in this case is effected by two currents starting from *x*, which thus becomes a neutral point, and passing through the end telephones to the ground, as shown by the arrows. If the ground be removed from the point, *y*, toward the telephone, *a*, the neutral point will be found to move toward telephone, *b*, and if the ground be put at the center of resistance of the telephone, *a*, the neutral point will be found to be at the center of the telephone, *b*. This is well illustrated in Fig. 7,

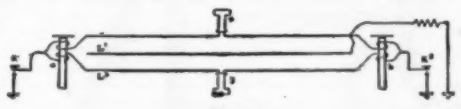


Fig. 7.

where *a* and *b* are telephones of special construction, admitting of the attachment of grounding keys, K^1 and K^3, at their respective centers. In this instance, when the disturbing wire is in operation and both keys open, no sound is heard at any of the telephones, the flow of current being lateral. If the key, K^1, be closed, sound is immediately heard at telephones, *x* and *y*, located at the centers of L^3 and L^3, but the telephones, *a* and *b*, are still silent. This is because the charge and discharge take place along the conductors, L^3 and L^3, to and from the earth at K^1, thus passing through *x* and *y*, *a* being silent because the currents go through it differentially, and *b* is silent because it is located at a neutral point. To prove that current flows through telephone, *a*, another telephone may be inserted in the ground branch at K^1, and it will be found to be loudly affected. If both keys, K^1 and K^3, are closed, silence is again obtained in the four telephones, *a*, *b*, *x*, *y*. In this case the charge and discharge from the wires, L^3 and L^3, divide at the center and flow back and forth at both ends, *x* and *y* being silent because they are at neutral points, and *a* and *b* are not affected by the currents which flow through them because of the differential action referred to.

Two systems have now been described, one in which the induced current is lateral, and the other in which it is longitudinal. I think it follows from the foregoing experiments that where wires are twisted about each other, as shown in Fig. 1, both of these actions are combined. At the left hand of Fig. 8 a cross section



Fig. 8.

of three wires, L^1, L^3 and L^3 (Fig. 1), is shown. In this position the wires occupy a place with reference to each other exactly as in Fig. 2, and the tendency of the disturbing wire is to cause a longitudinal flow in L^3 and L^3. If repeated cross sections of these wires are made, a point will be reached at which the three wires are disposed as shown at the right hand of Fig. 8, where it is seen that the disturbing wire, L^1, is at an equal distance from L^3 and L^3, and the tendency is to produce a lateral flow. The actual currents produced must be the resultant of these two actions.

Fig. 9 shows a plan quite different in principle from

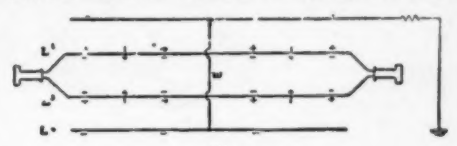


Fig. 9.

anything heretofore employed. It is of interest, not so much on account of any practical application which it may have at present, but because it is a very striking proof of the electrostatic nature of inductive cross talk between telephone circuits. L^1, L^3 and L^3 are the same wires as used in the previous cases, L^1 being half an inch from L^3, with the addition of an extra wire, L^4, placed half an inch from L^3 and joined by a conductor, *w*, with the disturbing wire, L^1. L^3 and L^3 are three feet apart. When in this condition the transmitter is operated, no disturbance whatever is heard in the end telephones; if the wire, *w*, be disconnected, the usual noise is heard, but is found to disappear as often as L^1 and L^4 are joined together. This action is explained by the fact that L^4 is at the same potential as L^1, on account of being joined to it by the wire, *w*, and acts with the same force on L^3 that L^1 does on L^3. The flow in this case is lateral, as indicated by the arrows, and the telephones are silent.

Neutral points may be produced in a circuit by the use of shunts. Fig. 10 shows the usual arrangement of

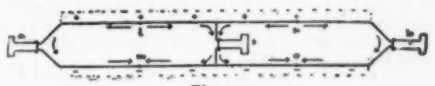


Fig. 10.

circuits with the telephones, *a* and *b*, at the ends, and another telephone, *x*, of equal impedance, branched between the two wires, at the center. In this case four neutral points are found, two in each wire. The currents produced by the discharge are indicated by the arrows. Thus by the addition of one shunt the disturbing currents in the end telephones have been reduced one-half. If similar shunts were placed at the quarters, the currents at the end telephones would be still further reduced to one quarter of their original strength.

This plant is not a practicable one, because of its shunting effect on the telephone current, but it is of value as showing one of the actions which occur when instruments are bridged into metallic circuits. It is interesting to note that in Fig. 10 the telephone, *x*, is affected by a current twice as great as that which flows through either of the end telephones.

Before closing I shall describe one more experiment. Fig. 11, L^1 is the disturbing wire and L^3 is a grounded telephone circuit placed one-half an inch from L^1. At

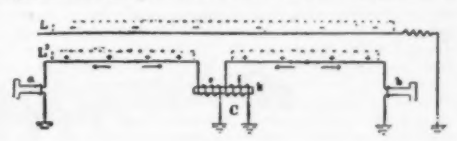


Fig. 11.

the center of L^3 there is an ordinary telephone repeating coil or transformer, C, containing two windings, *e* and *f*, of copper wire, each having a resistance of 160 ohms. One end of each winding is grounded, and the other end is connected to the line as shown. Assuming that the impedance of each telephone is equal to that of each coil of the transformer, a neutral point will be found at the center of each half of L^3, and the disturbing currents flowing through the end telephones will be only half as strong as though the transformer were omitted. If, now, the connections of the transformer be reversed, so that the discharges from the two sections of line pass through it in opposite directions, no magnetism will be produced in the core, *k*, and consequently the transformer coils offer an easier path to the discharge. This causes the neutral points to move toward the end telephones, and consequently reduces the disturbance still further.

I have not had an opportunity of trying this experiment with a transformer whose coils contained a low copper resistance and a high inductance, but according to theory, we might expect that such a transformer, having its coils connected differentially, should free a grounded line of considerable length from cross talk and other electrostatic disturbances. The number of such coils which can be worked in a given line is, of course, limited, but with properly designed apparatus a large number of them might be used. This arrangement is also interesting when considered with reference to electro-magnetic induction, and brings to mind a

* "A Hand book of Practical Telegraphy," R. S. Culley, 1885, p. 330. "The Telephone," Preece & Maier, 1889, p. 134. "Die Technik des Fernsprechwesens," Dr. V. Wietlisbach, 1886, p. 135.

question as to whether we may not at some future time abandon the use of metallic circuits and again make use of Steinheil's discovery.

[AMERICAN JOURNAL OF SCIENCE.]

RESTORATION OF TRICERATOPS AND BRONTOSAURUS.

By O. C. MARSH.

IN previous numbers of this journal the writer has given the principal characters of the gigantic *Ceratopsidæ*, or horned Dinosaurs, from the Laramie, with figures of the more important parts of the skull and skeleton.* The abundant material now available for examination makes it possible to attempt a restoration of one characteristic form, and the result is given in the plate. This figure, about one-fortieth of natural size, is reduced from a large outline plate of a memoir on this group, now in preparation by the writer for the United States Geological Survey.

This restoration is mainly based on two specimens. One of these is the type of *Triceratops prorsus*, Marsh, in which the skull, lower jaw, and cervical vertebræ are in remarkable preservation. The other specimen, although somewhat larger, is referred to the same species. It consists of parts of the skull, of vertebræ, the pelvic arch, and nearly all the important limb bones. The remaining portions are mostly taken from other remains found in the same horizon and localities, and at present are not to be distinguished specifically from the two specimens above mentioned. The skull as here represented corresponds in scale to the skeleton of the larger individual.

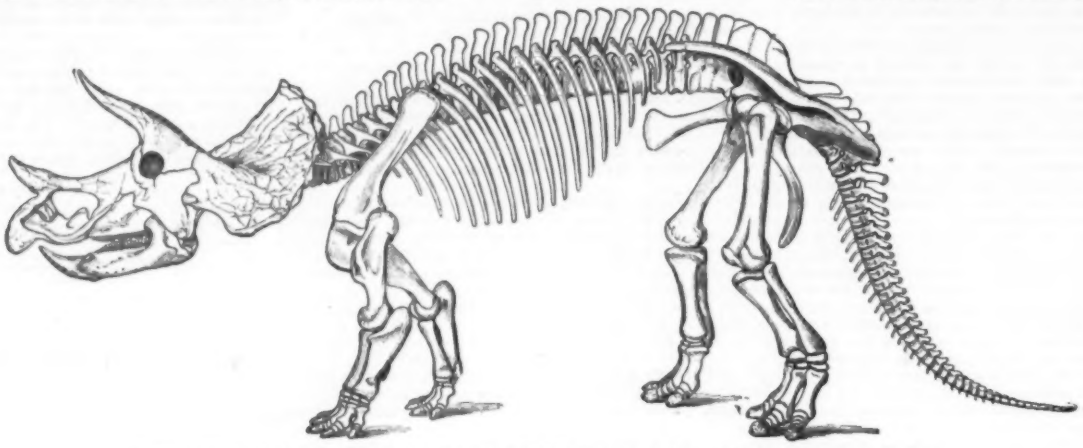
In this restoration, the animal is represented as walking, and the enormous head is in a position adapted to that motion. The massive fore limbs, proportionally the largest in any known Dinosaur, correspond to the head, and indicate slow locomotion.

The skull is, of course, without its strong horny covering on the beak, horn cores, and posterior crest, and hence appears much smaller than in life. The neck seems short, but the first six cervical vertebræ are entirely concealed by the crest of the skull, which in its complete armature would extend over one or two vertebræ more. The posterior dorsals with their double-headed ribs continue back to the sacrum itself, there being no true lumbars, although two vertebræ, apparently once lumbars, are now sacrals, as their transverse processes meet the ilia, and their centra are co-ossified with the true sacrum. The four original sacral vertebræ have their neural spines fused into a single plate, while the posterior sacrals, once caudals, have separate spines directed backward.

No attempt is made, in this restoration, to represent the dermal armor of the body, although in life the latter was more or less protected. Various spines, bosses, and plates, indicating such dermal armature, have been found with remains of this group, but the exact position of these specimens can, at present, be only a matter of conjecture.

This restoration gives a correct idea of the general proportions of the entire skeleton in the genus *Triceratops*. The size, in life, would be about twenty-five feet in length, and ten feet in height. The genus *Ceratops*, so far as at present known, is represented by individuals of smaller size, and in some instances, at least, of quite different proportions. A third genus, which may be called *Sterrholophus*, can be readily distinguished from the other two by the parietal crest, which had its entire posterior surface covered with the ligaments and muscles supporting the head. In *Ceratops* and *Triceratops*, a wide margin of this surface was free, and protected by a thick, horny covering. The type of the new genus is the specimen described and figured by the writer as *Triceratops flabellatus*, which in future may be known as *Sterrholophus flabellatus*, Marsh. There is some evidence that other forms, quite distinct, left their remains in essentially the same horizon of the Laramie, but their true relation to the above genera cannot be settled without further discoveries.

This group, so far as at present investigated, is very distinct from all other known Dinosaurs, and whether it should be regarded as a family, *Ceratopsidæ*, as first described by the writer, or as a sub-order, *Ceratopsia*, as later defined by him, will depend upon the interpretation and value of the peculiar characters manifested in its typical forms.



RESTORATION OF TRICERATOPS PRORSUS, MARSH. One-fortieth natural size.
[Size in life, about 25 ft. length; 10 ft. height.]

The main characters which separate the group from all other known families of the *Dinosauria* are as follows:

(1) A rostral bone, forming a sharp, cutting beak.
(2) The skull surmounted by massive horn cores.
(3) The expanded parietal crest, with its marginal armature.
(4) A pineal foramen.
(5) The teeth with two distinct roots.
(6) The anterior cervical vertebræ co-ossified with each other.
(7) The dorsal vertebræ supporting, on the diapophysis, both the head and tubercle of the rib.
(8) The lumbar vertebræ wanting.

The animals of this group were all herbivorous, and their food was probably the soft succulent vegetation that flourished during the Cretaceous period. The remains here figured are from the Ceratops beds of the Laramie, and were found by Mr. J. B. Hatcher, in Wyoming, on the eastern slope of the Rocky Mountains.

RESTORATION OF BRONTOSAURUS.

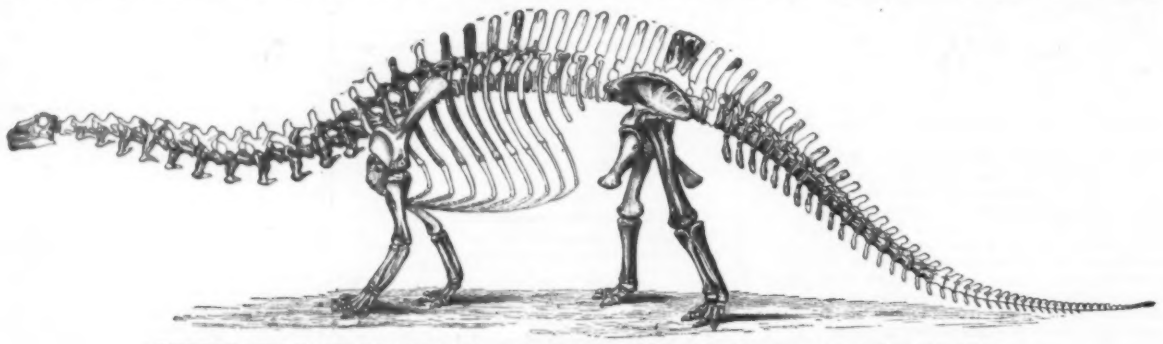
The plate is a restoration, one-ninetieth natural size, of another large Dinosaur, the gigantic *Brontosaurus* of the Jurassic. This differs so widely from *Triceratops* of the Cretaceous that a comparison of the two is most instructive. Each represents the dominant reptilian type of the period in which it lived, and each belongs to a distinct order of the *Dinosauria*. The older form, *Brontosaurus*, was more than double the size of the later *Triceratops*. The former represents a more primitive type, and the latter one highly specialized. Both show the early character of locomotion on all four feet, which many allied forms of each appear to have nearly or quite lost before their extinction.

In the restoration of *Brontosaurus*, the diminutive head will first attract attention, as it is smaller in proportion to the body than in any reptile hitherto known. The neck was very long and flexible. The body was rather short. The legs and feet were massive, and the bones all solid. The tail was very long and powerful. The animal during life must have been nearly sixty feet in length, and about fifteen feet in height. Its probable weight was more than twenty tons.

Brontosaurus was herbivorous in habit, and its food was probably aquatic plants, or other succulent vegetation. The skeleton here represented was found in the Atlantosaurus beds of the upper Jurassic, in Wyoming, west of the Rocky Mountain range.

The figure, one-ninetieth natural size, is reduced from a large restoration, one-twenty-fourth natural size, on a lithographic plate accompanying the monograph of the *Sauropoda*, prepared by the writer for the United States Geological Survey. In previous numbers of this journal will be found various papers by the writer on this group of Dinosauria, and among them, published in August, 1883, is a preliminary outline sketch of the present restoration.

New Haven, Conn., March 18, 1891.



RESTORATION OF BRONTOSAURUS EXCELSUS, MARSH. One-ninetieth natural size.
[Size in life, about 60 ft. length; 15 ft. height; weight, 20 tons.]

* This journal (3), vol. xxxvi., p. 477, December, 1888; vol. xxxvii., p. 334, April, 1889; vol. xxxviii., p. 173, August, 1889, p. 501, December, 1889; vol. xxxix., p. 81, January, 1890, p. 418, May, 1890; and vol. xli., p. 167, February, 1891.

THE ROYAL METEOROLOGICAL SOCIETY'S EXHIBITION.

THE twelfth annual exhibition of the Royal Meteorological Society was opened on March 3, in the rooms of the Institution of Civil Engineers, 24 and 25 Great George Street, Westminster. This year's exhibition is devoted to rain gauges and evaporation gauges, and such new instruments as have been constructed since the last exhibition. It might at first be thought that since an exhibition of rain gauges would be a very small and insignificant affair, and would not be of any interest to the general public. Any one, however, visiting the exhibition will at once see that a very large collection of various forms of range gauges has been got together by the society, and that the information obtained from the records of these simple instruments is of the highest importance. There are altogether fifty-six different forms of rain gauges shown in the exhibition, and it is interesting to compare the old with the new patterns.

Side tube rain gauges of various diameters are exhibited. In this instrument the water passes into the body of the gauge, and also into a glass tube in the front, and stands at the same level in each. As the combined area of these tubes is very much less than that of the receiving surface, the natural depth of the rain is proportionally increased, and thus the scale is lengthened in proportion—usually about eight or ten times—so that the quantity can be read off to hundredths of an inch. The objection to this form of instrument is that the glass tube is liable to be burst by frost, and the record lost.

Messrs. Negretti & Zambra exhibit a contracted float gauge, the receiver of which contains a copper float, to the upper side of which a rod is attached. When rain falls, the rod is lifted, and owing to the small area of the body of the gauge as compared with that of the rim, the float rises about eight times the natural depth of the rain.

Mr. Symons shows Fleming's rain gauge, which is a very small float gauge. This pattern was formerly much used in Scotland, but is now nearly abandoned, because when the quantity of rain collected exceeds two inches, rain which ought to pass over the gauge is caught by the measuring rod, and runs down it into the gauge. It was also usually placed so nearly level with the ground that surface water occasionally entered.

Various modifications of Howard's rain gauge are exhibited. This pattern was designed by Luke Howard, F.R.S., and engraved in the first edition of his "Climate of London," published in 1818. It simply consists of a funnel 5 in. in diameter, with a long tube at the bottom, which fits into the neck of a glass bottle. The area of the funnel is about eleven times that of the measuring jar, so that minute measurements can easily be made. In 1850 a stoneware bottle was substituted for that of glass, with the view of reducing the frequency of breakage. Mr. H. H. Treby modified this form of gauge somewhat by having rough divisions put upon the glass bottle, so that an approximate idea of the amount of fall might be obtained without the gauge being interfered with. Mr. Symons further modified this gauge by attempting to protect the glass bottle with an outer cylinder having two slits in it, so as to allow of inspection, as in Mr. Treby's gauge. This gauge, however, had two faults, viz., 1, the bottle did not hold enough; and 2, if it burst, the can, being pierced, could not save the water. This gauge

was subsequently so modified as to remove the above mentioned evils, the bottle being larger, and the can watertight.

Glaisher's rain gauge is 8 in. in diameter, and has a beveled rim and curved pipe. The rim round the gauge, about two-thirds of the way up, was designed to make a watertight joint, so as to prevent any of the rain inside escaping by evaporation. The same object was aimed at by the curved tube or inverted siphon, in which the last few drops of rain remained, and (until they dried up) formed a water seal. This gauge has subsequently been modified by the substitution of a vertical rim (to cut the rain drops) for the original beveled one on which they would break, and by the substitution of a long straight pipe for the curved one, which was found to be frequently choked with leaves, etc.

In the autumn of 1864 the late Major Mathew undertook to provide a number of gauges for the district round Snowdon; for that district Mr. Symons provided gauges 5 in. in diameter, with cylinders rising 4 in. vertically from the edge cone of the funnel. These are called "Snowdon rims," and funnels so provided are gradually displacing all others, because they are so much better in time of snow. A gauge of this kind in copper is nearly indestructible and independent of frost, because two vessels (one of glass and one of copper) must burst before the water can be lost. Specimens of this form of gauge, Symons' Snowdon, are shown both in copper and galvanized iron.

The Meteorological Office gauge, which is eight inches in diameter, is generally regarded as the best gauge for ordinary observers to whom cost is not a primary object; it has all the good features of the Glaisher and of the Snowdon patterns, and being of copper is very durable.

Several mountain rain gauges are exhibited. As these are for use in places where the rainfall is heavy, and where they can only be periodically examined, they are made to contain 40 or 50 in. of rain. The rod is detached from the float (to avoid error from its intercepting the rain), and is only dropped into the cup when an observation has to be made. The instrument has an outer cylinder to guard against frost, and to facilitate emptying.

The Manchester, Sheffield, and Lincolnshire Railway Company, who for many years past have had regular rainfall observations made at about fifty of their stations, exhibit a specimen of the gauge they employ, which is 8¼ inches in diameter, also a map showing the sites of their rain gauge stations and specimen of their forms and publication.

Mr. Symons shows a number of the original gauges which were employed about twenty-five years ago in the experiments carried out by Colonel Ward and others to determine, 1, the effects of placing gauges at different heights above the ground, not (as had been done previously) on buildings, but on posts; 2, to ascertain whether there is any difference in the indications of gauges ranging in diameter from 1 to 24 in., and including square ones of 25 and 100 in. area; and 3, to test the effect of various receiving surfaces, such as tin, copper, glass porcelain, and ebonite.

Among the other old pattern gauges may be seen: Stevenson's, which has the rim of the gauge brought to the level of the ground, and is surrounded by a brush to avoid in-splashing; FitzRoy's, in which the amount of rain is ascertained by a graduated dipping tube which has a hole at each end; the old copper gauge, with square funnel, used at the Kew Observatory from 1850 to 1890; and the coffee pot rain gauge—so called from its shape.

Mr. Symons shows both the first and second pattern of his storm gauges. These are not intended for general use, but to enable observers to watch the most minute details of heavy rain during thunderstorms. Carefully attended to, they yield information of the very highest importance, both for architects and for engineers, as to the rate at which rain falls. With one of these instruments in London, on June 23, 1878, rain was ascertained to be falling for 30 seconds at the rate of 12 inches an hour.

The earliest registering rain gauge is probably that known as Crosley's. The area of this gauge is 100 inches, and beneath the tube leading from the funnel there is a vibrating divided bucket; when one compartment has received a cubic inch of water, *i. e.* 0·01 inch of rain has fallen, the bucket tips, the index advances on the first dial, and the other bucket begins to fill, and so on indefinitely. Messrs. Yeates & Son's electrical self-registering rain gauge is simply a Crosley gauge, in which electrical contact is made at each turn of the bucket, and the index hand moved one division. The advantage of this instrument is that the funnel may be placed in any exposed position out of doors, while the registering part can be fixed indoors.

The Kew Committee exhibit Stutter's registering rain gauge, which has twenty-four collecting jars, one for each hour, and also Beckley's self-recording rain gauge, which is the pattern in use at the observatories in connection with the Meteorological Office; its funnel has a receiving area of 100 square inches, and is provided with a lip 1¼ inch deep, to retain the splashes. The rain flows down into a copper receiving vessel, which, floating in a cistern of mercury, sinks and draws down with it a pencil which marks on a cylinder moved by a clock. When the receiving vessel is full, a siphon comes into action and rapidly draws off the whole of the water, the vessel rising almost at a bound, the action being recorded by a vertical line on the cylinder. Mr. Casella shows the recording portion of his self-recording gauge, which is another mode of effecting the same object.

MM. Richard Freres, of Paris, exhibit two of their self-recording rain gauges, which are very ingenious instruments and promise to yield good results. They are already at work at many stations on the Continent, and to our own knowledge at four in this country.

Several rain gauges as used in foreign countries are included in the exhibition. Prof. Mascart, of the Bureau Central Meteorologique de France, has sent four specimens of gauges as used in France; and Dr. Hellmann, of the Kon. Preussisches Meteorologisches Institut, Berlin, has forwarded the first and second patterns of his rain and snow gauge (the latter of which is now used in the Prussian Meteorological Service), and also his gauge for measuring the density of snow. Wild's rain gauge, as used in Russia, and Nipher's protected snow gauge, as used in the United States, are also exhibited.

Among the miscellaneous gauges may be mentioned the marine rain gauge, mounted on gimbals for use on board ship; Livingstone's rain gauge, with funnel 3 in. in diameter, as made for the late Dr. Livingstone; tropical rain gauge, with funnel 4½ inches in diameter, and receiver large enough to hold 40 inches of rain; Colladon's gauge for determining the temperature of hail; Sidebottom's snow-melting rain gauge; and Mawley's snow gauge.

Perhaps the largest rain gauge that has ever been made is that employed by Sir J. B. Lawes and Dr. J. H. Gilbert on their experimental farm at Rothamsted; this has an area of one-thousandth of an acre. The funnel portion of this large gauge is constructed of wood lined with lead, the upper edge consisting of a vertical rim of plate glass beveled outward. The rain is conducted by a tube into a galvanized iron cylinder underneath, and when this is full it overflows into a second cylinder and so on into a third and fourth, and finally into an iron tank. Each of the four cylinders holds rain corresponding to half an inch of depth, and the tank an amount equal to 2 in. Each cylinder has a gauge tube attached graduated to 0·002 in. Of course, this gauge itself could not be exhibited, but two of the collecting gauge cylinders are shown, as well as a colored view of the gauge *in situ*, drawn by Lady Lawes. A colored view of the Rothamsted drain or percolation gauges, drawn by Lady Lawes, is also shown. There are three drain gauges, each one thousandth of an acre area, which are used for the determination of the quantity and the composition of the water, percolating respectively through 20, 40, and 60 inches depth of soil (with the subsoil in its natural state of consolidation). Sir J. B. Lawes and Dr. Gilbert exhibit a table giving the results of rainfall and drainage at Rothamsted for the twenty harvest years ending August 31, 1890. The annual means are as follows:

Rainfall.	Drainage through soil (uncropped.)			Difference approximately =evaporation.		
	20 in.	40 in.	60 in.	20 in.	40 in.	60 in.
in.	in.	in.	in.	in.	in.	in.
30·29	14·38	15·16	43·61	15·91	15·13	16·68

The exhibition also includes a number of evaporation gauges for determining the amount of evaporation from a free surface of water or from plants. The Meteorological Council exhibit Von Lamont's atmometer, and Wild's, De la Rue's and Piche's evaporimeters; Mr. Casella shows Babington's atmidometer, and an 8 inch pedestal evaporator. Dr. W. G. Black shows his floating rain gauge and evaporating cup for use on ponds; and Mr. W. H. Dines exhibits the apparatus used by the late Mr. G. Dines for measuring evaporation. Mr. Symons shows the following from the series of evaporators constructed under the supervision of Mr. Rogers Field, and used in experiments at Stratfield Turgiss about twenty years ago, viz., Fletcher's, Watson's, Miller's wet sand, tin, tin with overflow, Casella's can and bottle; also Field's hook gauge, used for determining the depth of water evaporated from the large tank, 6 ft. square and 2 ft. deep, which was used as the standard wherewith the foregoing and some other forms of instrument were compared. The Cambridge Scientific Instrument Company exhibit a self-recording evaporimeter, designed for use with growing plants in a botanical laboratory; and MM. Richard Freres, show their self-recording evaporation gauge for use with either water or plants.

Several new instruments are also shown in the exhibition, among which may be mentioned the following: Latham's self-recording apparatus for wells, rivers, and reservoirs; Dines' and Munro's helicoid and Robinson's anemometers, and helicoid air meter; and Richard Freres, statoscope (which is a very sensitive atmospheric barometer) and anemo-cinemograph. Mr. Clayden exhibits a small and large camera for meteorological photography, showing a simple method of attaching a mirror of black glass for photographing meteorological phenomena. The Kew Committee exhibit the frames designed by General Strachey and Mr. Whipple for measuring cloud pictures for determining the height and drift of clouds.

The exhibition also includes a large number of photographs illustrating meteorological phenomena, etc., as well as a number of maps and diagrams showing the distribution of rainfall over various parts of the world. —*William Marriott, in Nature.*

THE PHOTOGRAPHY OF SELF-LUMINOUS SUBJECTS.* INCLUDING PYROTECHNICAL PHOTOGRAPHY.†

By Dr. W. GOULD LEVISON.

IN that branch of photography which deals with self-luminous subjects, the specialties of solar and celestial photography have been chiefly developed, although others of later origin and perhaps of wider interest are included. Pyrotechnical photography, in so far as it embraces effects in fire, is one of these next likely to acquire prominence.

My acquaintance with the latter feature of it dates from the evening of Pain's day at Manhattan Beach, September 13, 1884, when I exposed a plate in a small hand camera upon an exhibition piece near which I was standing on the lawn. The resulting negative suggested that, with experience, very attractive pictures of such subjects might be obtained.

The present communication is a record of the results of a series of experiments which originated in this incident, with additional illustrations from other sources; but it also extends to the photography of self-luminous subjects other than fireworks. In this paper, the word "subject" is employed as a technical term pertaining to the fine arts, and not as an equivalent for the word "object."

On September 17, 1887, I again attempted to photograph one of Messrs. Pain & Son's designs in fireworks, which was occasionally shown at Manhattan Beach during that year, entitled "The Battle of the Monitor and the Merrimac." This picture includes one or two set pieces and affords an interesting study. The plate was exposed nearly all the time that the lances of the set pieces continued to burn, yet although they are quite actinic, they have not seriously halated it. The torrent of Roman candle balls which, in the view, the Merrimac is pouring upon the Monitor resembles a stream of water from a fire engine hose; but in the original production these balls were projected separately, and successively traced their trajectories upon the plate. As the lens was open throughout the engagement, all the projectiles are accumulated in the picture and the terrors of the combat thereby greatly enhanced.

Such pictures as this are taken by the extremely simple method that is resorted to for photographing a flash of lightning at night. The camera is simply aimed where the discharge is to appear, and left open until it has occurred. When sufficiently sensitive plates are made, the astronomer, by this method, may register every meteor in a meteoric shower.

All fireworks, however, cannot be so easily photographed. If the camera be left open before a piece discharging a shower of fine sparks, each is separately photographed, but the numerous superposed images obliterate each other. This was illustrated by a view of a large wheel taken at Manhattan Beach on August 22, 1889; while a second view taken on September 17, 1887, by an exposure continued only during one revolution of a similar wheel, afforded the outer fringe in exquisite detail.

Since the summer of 1888, Mr. George S. Wheeler participated with me in several experiments; and as a result of but three visits with him to Messrs. Pain & Son's exhibitions, a number of charming views were obtained which, together with those mentioned, afford a fair abstract of an evening with the fireworks at Manhattan Beach. The series includes an exhibition piece taken August 21, 1889, views of the large fountain and mines and the eruption of Vesuvius and the burning of Pompeii, taken August 22, 1889, and the final flight or bouquet of rockets taken August, 1888.

M. Albert Londe, of Paris, has made a number of large negatives of display fireworks, at various times. He has very kindly made and sent me a number of lantern slides from these negatives. They include views of bombs and gerbs, parachute gerbs, a revolving wheel, a bouquet of flowers, and a display from the second story of the Eiffel Tower, taken on July 14, 1888. Mr. F. L. Lathrop, of Brooklyn, N. Y., has also made a few indifferent negatives of fireworks which were part of the Inaugural Centennial display on Fort Greene, Brooklyn, N. Y., about May 1, 1889. The views presented comprise perhaps most of the more important at present in existence.*

From such subjects, we passed, at the suggestion of Mr. Wheeler, to photographing small pieces, chiefly Catharine and triangle wheels, hoping to accumulate on one plate the trajectories of all the sparks emitted by such a wheel, and thereby to produce a picture resembling that of a large piece. The pictures at first obtained only approximately afforded the expected result. The flame at the mouths of the cases produced a marked effect, but the trajectories of the sparks were less distinctly traced, owing either to their smallness, rapid flight, or low incandescence. Four-ounce triangles, rosette wheels, China fliers, and ten-inch vertical wheels all gave outer fringes in which the detail of the sparks was easily obliterated by long exposures, owing to the number and superposition of their images.

Seeking to obtain small wheels affording large and brilliant sparks, like those emitted by exhibition pieces, I found that the sparks from these were due to steel filings, which are not put in commercial wheels, as they are liable to be destroyed by rust before such pieces are used. From ten-inch vertical wheels containing steel filings, zinc filings, and powdered magnesium, made especially for me by the Unexcelled Fireworks Company, very attractive pictures were finally obtained. The so-called pot usually attached to small wheels, and consisting of a case of Bengal fire, was found to overpower the discharge from the driving-cases, both by halation and illumination of its own smoke, unless it was arranged to light at the last moment and was photographed by a separate short exposure. From these experiments, it was concluded that the ideal small wheel for photographing should emit sparks about one-tenth of the size of Roman-candle balls, and might have one or two pots arranged to light without an explosion and burn only during one revolution of the wheel.

The "ghost," or reflection from the lenses, which is of less moment in ordinary photography, becomes so conspicuous in pyrotechnical photography as to be a matter of considerable solicitude. Views of wheels were presented in which an additional image resembling the circular ornament in the center of the wheel appeared near the edge of the plate. That its circular form is not dependent on that of the primary image was shown by pictures in which candle and lamp flames photographed by short exposures were accompanied by very distinct circular impressions obtained by longer exposures. In making some of these views, screens were used close to the plate-holder, to cover portions of the plate. The effects and the avoidance of these reflections in pictures by artificial lights were discussed at length and illustrated by portraits taken by lamplight.

The next following views, showing brilliant haloes of several forms, obtained from the sun with various lenses, illustrated that the so-called halo which surrounds the disk of the sun, when it is located in or near the center of the plate, moves from the center of the plate in one direction in proportion as the sun moves away from the center in the opposite direction. It was assumed that a bright star would afford a similar halo with sufficient exposure. This led to the suggestion that photo-telescopic lenses should be rigorously investigated in this respect, and that it should be demonstrated that such objects as the celebrated nebula in the Pleiades (which is revealed only by the photographic plate) are neither wholly nor in part an aggregate of such reflections from the group of stars within the field of view.

Photographs of Geissler tubes taken by exposures not exceeding five seconds in duration, and showing the stratified discharge in nitrogen, hydrogen, and carbonic anhydride, were next presented. The stratification was best obtained by a number of separate flashes made at about half-second intervals by breaking the primary current by hand. These were followed by other photographs of a Crookes tube, showing the mean free path of radiant matter, in which the differ-

* A paper read before the Brooklyn Academy of Photography, November 26, 1889.

† Paper read before the N. Y. Academy of Science, February 10, 1890, and the Photographic Department of the Brooklyn Institute, February 11, 1890.

* I have since seen an example given by M. Abel Buguet—*Journal des Societe Photographiques*, January, 1890.

ent phenomena resulting from reversed polarity and shifting the connections were distinctly portrayed. The photographing of the high tension discharge in these various vacuum-tubes appeared to afford the following conclusions:

1. The bands of the stratified discharge seem to recur more nearly at the same points of origin when the primary current is broken at moderate intervals.

2. Either variety of discharge affords an impression with a Cramer (s 40) plate in five seconds or less; hence but a short exposure would probably be required to photograph not only the form but also the detail of polar auroræ. The reduction by the lens, and consequent concentration of the light, would probably lessen even this short exposure.

3. If comets are foci of radiant matter,* they may be photographed by short exposures.

Divers series of lantern views and negatives next followed, showing the effects obtained in several similar cameras simultaneously exposed, on the same self-luminous subject, but charged with various plain and ortho-chromatic plates. Carbutt's eclipse and eclipse ortho-chromatic plates made of the same emulsion; imported and American eoside; and plain Cramer (s 40) plates were employed. The spectra of barium and strontium, fireworks, and Geissler tubes afforded subjects. Cramer plates unstained developed the strongest impression of the latter subjects. In case of the spectra, the lines of the barium spectrum between *e* and *a* affected the stained and not the plain plate; but with the same exposure of several minutes, only the blue line of the strontium spectrum distinctly affected either plate, and that appeared to affect both about equally. Pure hydrogen gas, giving no spectrum of its own, was the flame employed.

The subject of reversal of the image was next discussed, and illustrated by several examples occurring in the case of fireworks, Geissler tubes, and direct views of the setting sun. From these it was concluded that important revelations might result from photographing objects illuminated successively by monochromatic lights of various wave-lengths; as an antagonistic or complementary action between the more and the less refrangible rays, most pronounced between the blue and red, seems to be concerned in reversals.

The utility of the photography of self-luminous subjects was next considered: and in illustration of its application for preserving historical mementoes, there were presented, first, a view of the burning Brooklyn Tabernacle at night, and next a view, by M. Albert Londe, of the illumination of the Trocadéro in Paris at the opening of the exposition.

But its utility was considered as more apparent in the production of combination exposures. These were exemplified by an interior daylight view of the electric exhibition in Philadelphia, decorated with electric lamps, taken on September 27th, 1884, and a daylight view of a zinc-furnace in operation, showing the flames of the burning zinc escaping from the mouths of the retorts. Another variety of combination exposures was typified by a portrait of a smoker lighting his pipe near a lighted lamp—the lamp and match flames being taken by direct exposure, the portrait by flash-light.

Finally, a picture of a watch-spring burning in oxygen, obtained by the same method, was shown as perhaps the first of its kind and likely to be followed by views of other experiments, as of antimony and arsenic burning in chlorine; and it was suggested that photo-engravings of such pictures should soon replace the woodcuts now used in text-books.

The paper was illustrated by about seventy-five original and highly novel lantern views, many of which, by Dr. Levison, were shown for the first time.

AN EASY METHOD OF FINDING THE UNITS OF HEAT OF COMBUSTION OF GASEOUS MIXTURES.

By Mr. EDWARD C. JONES.

THE value of gases as lighting agents has always been expressed in candle power, and we are all familiar with the instruments used to determine the value of gas in standard sperm candles. Since the inception of the gas business it has been the aim of many gas engineers to simplify the apparatus used for taking candle power, and supply easy methods of working out results, until now the gas consumer, as well as the gas maker, knows an 18 candle gas, and understands its value when compared with gases of other candle power. The convenience, cleanliness and economy of the use of gas as fuel, and the fact that the use of natural gas in Southern and Western cities has educated people in the use of gaseous fuel until it has become a necessity, has brought forward many excellent methods of making fuel gas. Nearly all the gases made expressly for fuel purposes are non-luminous, or, at most, only partly luminous, and their value cannot be measured by photometry, but must be expressed by a standard of heating power or heat units.

The British heat unit is the amount of heat that will raise the temperature of one pound of water 1 degree F., and this unit is extensively used in English-speaking countries as the standard of value of a gas for heating purposes. The heat of combustion of one pound of different gases has been carefully computed, from results of J. Thomsen in A. Naumann's *Die zie Hungsfrage* (Gissen, 1882, p. 61) as follows:

Hydrogen.....	61,524	heat units per pound.
Carbonic oxide..	4,395·6	" " " "
Marsh gas.....	24,021·	" " " "
Olefiant gas.....	21,524·4	" " " "

These include all the combustible gases found in the various fuel gases, including coal gas, water gas (carbureted), natural gas and fuel water gas, with the exception of numberless hydrocarbons which make up the class of illuminants. These are classed as olefiant gas, and in calculating heat units of illuminants the results are approximately correct. The value of the different constituent gases being known, the usual method of finding the heat units in a mixture of gases is to multiply the quantity of each gas (usually expressed in the percentage of a cubic foot) by the weight of a cubic foot, and then multiply the product by the number of heat units in a pound. This process is long and tedious, and few active, busy men have time for such lengthy calculations. Yet it is desirable to know the heating value of a gas, and it becomes more desirable and even necessary as the use of gas for fuel purposes increases.

The first step to simplify the process of figuring is to determine the number of heat units in a cubic foot of different combustible gases. This is done by multiplying the weight of a cubic foot in fractions of a pound by the number of heat units in a pound, thus:

	Weight per Cubic Foot.		Heat Units per Pound.		Heat Units per Cubic Foot.
Hydrogen ...	0·005594 lb.	×	61,524·0	=	344·165
Carbonic oxide	0·07809224 lb.	×	4,395·6	=	343·262
Marsh gas.....	0·04466809 lb.	×	24,021·0	=	1,072 972
Olefiant gas...	0 07814818 lb.	×	21,524·4	=	1,682 092

We find that

Hydrogen has....	344	heat units per cubic foot.
Carbonic oxide...	343	" " "
Marsh gas.....	1,073	" " "
Olefiant gas.....	1,682	" " "

To further simplify the process, dividing the above figures by 100 gives a constant multiplier for each gas, as follows:

Hydrogen.....	3·44	Marsh gas.....	10·73
Carbonic oxide.	3·43	Olefiant gas....	16·82

The preparation of each component part in a mixture of gases is usually expressed in per cent. or hundredths by volume. An analysis of ordinary coal gas would appear as follows:

Nitrogen	2·10	Marsh gas.....	34·00
Carbonic acid...	1·00	Hydrogen.....	50 21
Illuminants	5·19		
Carbonic oxide..	7·50		100·00

To ascertain the number of heat units developed in the combustion of this gas, it is only necessary to multiply the volume of each gas, as expressed, by the constant of the gas.

Nitrogen.....	2·10			
Carbonic acid.	1·00			
Illuminants...	5·19	× 16·82	=	87·29 units.
Carbonic oxide	7·50	× 3·43	=	25·72 "
Marsh gas....	34·00	× 10·73	=	364 82 "
Hydrogen	50·21	× 3·44	=	173·72 "
	100·00			650·55 British heat units

and we find that the gas will develop 650 units per cubic foot.—*Amer. Gas Light Jour.*

* Papers of the American Astronomical Society, No. 3; Brooklyn, N. Y., March, 1887, page 54.

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